1st International Conference on Surface Science
25-26 April, 2019
Innovations and Applications for Geoenvironmental Challenges

ABSTRACT BOOK

Editors
Safdar Bashir, Nabeel Khan Niazi, Zubair Aslam
Khalid Hussain, Zulfiqar Ahmad Saqib, Irshad Bibi

INSTITUTE OF SOIL & ENVIRONMENTAL SCIENCES
Arsenic Contamination Assessment and Remediation (Arsenic CARe) – A Global Network
UNIVERSITY OF AGRICULTURE FAISALABAD, PAKISTAN 2019

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SURFACE SCIENCE: INNOVATIONS AND APPLICATIONS
FOR GEOENVIRONMENTAL CHALLENGES
APRIL 25-26, 2019

EDITORS: SAFDAR BASHIR, NABEEL KHAN NIAZI, ZUBAIR ASLAM, KHALID HUSSAIN, ZULFIQAR AHMAD SAQIB, IRSHAD BIBI

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INSTITUTE OF SOIL & ENVIRONMENTAL SCIENCES
Arsenic Contamination Assessment and Remediation (Arsenic CARE) – A Global Network
University of Agriculture Faisalabad, Faisalabad 38040, Pakistan
AGENDA OF CONFERENCE:

SS-IAGEC 2019 will be unfolding various intriguing aspects occurring at solid-water interface; applications of surface analytical techniques in Agriculture, Earth and Environmental Sciences, Nuclear Materials research, Biomaterials, Biochar, Nanomaterials and Biogeochemical research.

The overarching aims of this conference are to create awareness and develop capacity among researchers, students and relevant stakeholders about the significance of Advanced Surface Analytical Techniques and their applications in a wide range of scientific disciplines and industry.

This activity will be helpful to make a contribution to reaching the Sustainable Development Goals (SDGs), in particular SDG 3 (good health and well-being), SDG 6 (ensure the availability and sustainable management of water and sanitation for all), SDG 13 (climate action), SDG 14 (life below water) and SDG 15 (life on land).

OBJECTIVES:

The objectives of this conference are to highlight the key advancements in the field of Environmental Geochemistry, Material Sciences and Nanotechnology. This mega event will also provide a great platform to devise the robust strategies for future interventions and providing real world solutions to Geoenvironmental challenges.
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Plenary Speeches
HOW DO WE PREDICT THE DISSOLUTION AND GROWTH KINETICS OF CRYSTALLINE MATTER?

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Modern industrial societies face a mix of environmental and technical challenges such as fighting/avoiding water pollution (e.g., 1), generating safe (nuclear) waste deposits, controlling cement quality, and managing carbon sequestration successfully and safely. Therefore, societies rely critically on comprehensive mineral dissolution and material corrosion rates. In many cases, it is not sufficient to just measure the reaction rates but it is also mandatory to predict the behavior of complex solid-fluid systems into the future. Such challenging task requires contributions from various scientific and engineering disciplines - and earth and material sciences are at the forefront. At the same moment, geologists, mineralogist and geochemists are used to measure the present state and reconstruct the past. Consequently, we now need to develop a new approach with the necessary tools to predict future system behavior. An ever growing multitude of new and more sophisticated experimental and analytical tools and techniques has demonstrated that crystal dissolution creates an almost overwhelming complexity at the dissolving or growing interface (e.g., 2-5). In response, we have generated an impressive pool of data and detailed observations that shed some light and provoke always more questions. Currently, parameterized Kinetic Monte Carlo simulations show some potential for correctly predicting crystal dissolution (e.g., 6, 7). These first results raise a surprising question: Does just a “handful” of simple basic processes govern the reaction kinetics and create at the same time the tremendous complexity that we observe? There are some interesting arguments that this may be indeed the case. The answer to this question is important because spatially resolved dissolution and growth rates present the “reactive term” in reactive transport models.

Keywords: Dissolution; minerals; crystalline

FUNCTIONALIZED BIOCHAR FOR SOIL AND ENVIRONMENTAL APPLICATIONS

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Biochar is a carbon-rich material that is produced by pyrolysing organic biomass at high temperatures, usually between 300 and 600 ºC. The concept of biochar application to soils was originated based on the observations of increased carbon and improved fertility in the Amazonian Black Earths (Terra Preta de Indio) compared to the native soils. Research in the last two decades has established the potential of biochar in the long-term carbon storage in soils, with a residence time of well over 100 years for a large proportion of biochar-C. Biochar application has also been promoted to increase soil fertility or crop productivity, improve nutrient- and water-use efficiencies, mitigate greenhouse gas emissions and reduce the availability of toxic compounds in soils. However, there is a large variability and sometimes negative or no yield responses from biochar application to soils. Because of this, the biochar technology has not been widely adopted by farmers and land managers.

In the last few years there has been increased emphasis on the environmental applications of biochar, particularly in the remediation and management of contaminated soil and water. Although most of the carbon in biochar is present in the ring structure, biochar surfaces can be functionalised via chemical oxidation or by producing biochar composites with other natural materials, such as, phyllosilicates and metal oxides. Research on functionalised biochars for targeted environmental applications have accelerated in recent years. Some examples of tailor-made biochars for agricultural and environmental applications including the sorption of organic and inorganic contaminants will be discussed in the presentation. It is expected the use of biochar in such applications will increase in the future, considering it is relatively cheap, environmentally sustainable and can be potentially tailored for a wide range of applications and all types of chemical contaminants, including heavy metals and organic compounds.

Keywords: Biochar, Environment, Soil
Invited Speakers
Covalently anchored thin “Polymer Coatings” have emerged as a convenient tool for achieving a variety of functional materials. The key advantages of such polymer coatings are their mechanical robustness and chemical stability. In addition, a provision of high degree of synthetic flexibility towards the introduction of a variety of functional groups has made these polymer coatings attractive for fabrication of materials with controlled surface properties like cell adhesion/biocompatibility, wettability, coloring, stimuli responsiveness, water remediation, catalysis etc. The scope and relevance of the surface anchored polymer chains for modulating the surface properties of solid-state nanopores (polymeric and non-polymeric) and a variety of nanomaterials (e.g., silica nanoparticles, magnetic nanoparticles, and carbon nanomaterials) for application in the fields ranging from environment to energy will be presented. In addition, some of our recent work related to application of polymer-based nanomaterials in addressing health related challenges will also be discussed.

Keywords: Porous Material, Energy, Environmental Challenges
ENVIRONMENTAL EXPOSURE OF NANOPARTICLES: NUTRIENT AVAILABILITY, PLANT GROWTH, TOXICITY AND FOOD CHAIN CONTAMINATION

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Titanium dioxide nanoparticles (TNPs) are among the widely used engineered NPs in commercial products. Such large production has led to their increased release into natural ecosystems, where these NPs may interact with plants and largely affect their physiological functions. The aims of present work were to investigate the effects of TiO$_2$ nanoparticles (TNP) on phytoavailability of phosphorus, growth response of different crops such as Lettuce, rice and wheat and, TiO$_2$ nanoparticles impacts on animal model in order to evaluate risks in case of their entry into food chain. Soil was spiked with different levels of TNPs. All the experiments were repeated three times and four replicates for each treatment were maintained every time. After 60 days of exposure time, root and shoot lengths significantly (p<0.05) increased at 20-60 mg kg$^{-1}$ of TNPs compared to the control and then the lengths decreased at 80 and 100 mg kg$^{-1}$ for wheat plants. The similar trend was observed for uptake of P by plants. The Chl content was measured for 16 alternative days after 30th day of TNPs exposure time till the end of experiments. There was gradual increase for lettuce till 100 mg kg$^{-1}$ dose and no toxicity was observed. For rice crop, the dose for any considerable effect was very high and the optimized dose appeared as 500 mg kg$^{-1}$. These differences highlight varietal response to application of nanoparticles. 30 one-day-old chicks were randomly divided into five groups i.e. control, T1, T2, T3 and T4, served with different doses of 0, 10, 20, 40 and 80 mg kg$^{-1}$ respectively. After 42 days blood samples were analyzed for Cholesterol (CHOL), High density lipoprotein (HDL), Triglycerides (TG), Alanine amino-transferase (ALT), Alkaline phosphatase (ALP), Blood urea nitrogen (BUN) and Creatinine (CREA) levels for evaluating impacts of TNPs on liver and kidneys. All biochemical parameters showed no significant impact except for Blood urea nitrogen (BUN) and triglycerides. Lowest TG level was observed at T2 which was significantly different (p<0.05) from control group while BUN levels of all treatments were significantly (p<0.05) lower than control. TNPs also showed no significant improvement in development of native birds.

Keywords: Nanoparticles, Plant growth, Contamination, Nutrient Availability
ICSS/IAGC/2019/OP/05

PHYTOREMEDIATION OF HEAVY METAL CONTAMINATED SOILS: A COMPARISON OF MECHANISMS AT CELLULAR LEVELS

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Despite significant recent advancements in research, the efficiency and effectiveness of different types of remediation technologies for the clean-up of toxic pollutants are still noteworthy and topical. In recent past, numerous technologies involving the use of plants have been developed for the clean-up of environment. Some technologies have long been in use to remediate the hazardous heavy metal(loid)s. Conventional remediation methods for heavy metal(loid)s are generally based on physical, chemical and biological approaches, which may be used in combination with one another to clean-up heavy metal(loid) contaminated soils to an acceptable and safe level. This talk will highlight and compare the pool of available technologies that are currently being applied for remediation of heavy metal(loid) contaminated soils, as well as the economic aspect of soil remediation for different techniques. The topic will also cover an assessment of the contemporary status of technology deployment and recommendations for future remediation research. Especially, the talk will compare the cellular mechanisms of phytoremediation of heavy metal contaminated soils. It will highlight, why it is necessary to carry out risk assessment before phytoremediation. Finally, the molecular and genetic basis of heavy metal(loid) (hyper)accumulation and tolerance in microbes and plants will also be discussed.

Keywords: Phytoremediation, Heavy Metal, Contaminated soils
APPLICATION OF FLOATING AND CONSTRUCTED WETLAND FOR THE REMEDIATION OF DOMESTIC AND INDUSTRIAL WASTEWATER

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Water reservoirs are being polluted largely by discharging wastewater of residential colonies and industries into water resources. In developing countries, wastewater treatment is difficult because of conventional wastewater remediation technologies are not sustainable due their high capital and operational/maintenance costs. The use of floating and constructed wetlands is an innovative approach in Pakistan for the remediation of water contaminated with organic and inorganic pollutants. It is a cost effective and sustainable approach with no/minimum operational and maintenance costs. The plants and their associated microorganisms, colonizing on/in the roots and shoots, degrade the organic contaminants, whereas inorganic pollutants like nutrients and potential toxic metals are taken up by the plants. We have developed both floating and constructed wetlands using locally available plants, floating mat, and gravel, and inoculated these with potential bacteria. Our developed processes have been successfully applied in different contaminated sites for the remediation domestic and industrial wastewater in Pakistan. Up to 90% removal of both organic and inorganic pollutants from the wastewater has been achieved with efficient growth of plants and bacterial proliferation.

Keywords: Wetlands; remediation; plants; wastewater
EMERGING THREATS TO PAKISTANI CONIFEROUS FORESTS: ROLE OF PLANT PROPAGATORS IN KEEPING A SUSTAINABLE FOREST COVER

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Management of Pakistani forests have seen many challenges in the past, however, the problems are increasing at an alarming rate now due to a huge population explosion. There are issues that are perhaps related more to policies and shall very briefly be discussed in this presentation. More emphasis shall be on the work of plant propagators in general and with an emphasis on somatic embryogenesis technique that has got a potential to reclaim high quality pine trees abundant but endangered in Pakistani pine forests. The soil-plant system that existed for a rather long time undisturbed seems to have been disturbed during the past many years. Nonetheless, it can be partly, if not fully, recovered by a combination of approaches. Plant propagators can play a role in it and this shall be the basis of this presentation.

Keywords: Sustainable, Coniferous forest, plant propagators
SOIL C SEQUESTRATION IN PAKISTAN: CURRENT STATUS AND POTENTIAL OPPORTUNITIES

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Soil organic carbon sequestration is the key function of soil and considered as finest mitigation strategy to combat climate change and food security challenges. However, this is controversial in terms underlying mechanisms. This is due to lack of data and knowledge gaps regarding stocks and flows of organic carbon and its controls. Despite large amount of research on this topic worldwide, soils of Pakistan, an agriculture-based economy, are still uninvestigated. Most of the agriculture in Pakistan is practiced in semi-arid to arid regions whereby high temperatures and extractive farming practices are precluding buildup of soil organic C. First there is a need to ascertain if increasing the SOC is possible in such conditions. Secondly, the controls on SOC stabilization need to be established. We have identified the edaphic and climatic controls on SOC cycling/stabilization in Pakistan soils by studying the soils from various climates of Pakistan. Moreover, we also have established that the SOC sequestration is possible. The need is to identify suitable land management practices and disseminating them through suitable media and extension programs.

Key Words: Soil organic C, C sequestration, agriculture, forestry
MICROBIAL ISOPROTURON DEGRADATION IN SOIL AND AQUEOUS MEDIA: UNVEILING THE PHENOMENON AND PROCESSES

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Isoproturon [3-(4-isopropylphenyl)-1,1-dimethylurea (IPU)], one of the phenoxy herbicides, is extensively used across the globe in agricultural fields to overcome the pre- and post-emergence of broad leaf weeds in cereal cultures. Intensive use of IPU is becoming a source of ground and surface water contamination. Several problems including cancer, endocrine disruption and inhibition of growth in humans, animals and plants are related to IPU toxicity. Keeping in view the environmental concerns associated with IPU, there is a need to develop the strategies for removal of IPU from our environment. In this regard, a number of recent studies indicate that microbial degradation of isoproturon in the soil and aqueous media might serve as an efficient way to control the dispersion of this herbicide in the environment. The data from these studies indicate that soil microbial degradation of IPU is one of the main phenomena governing the fate of this herbicide in soils. However, it was being controlled by different physicochemical characteristics including pH, CEC and organic matter content prevailing in soils. Moreover, different bacteria having the potential to degrade IPU were also isolated and characterized from these soils. The studies indicated that the bacteria especially the bacteria belonging to genera *Sphingomonas* and *Sphingobium* have a good potential for degradation of IPU in the soil as well as aqueous media. These bacteria were found to mineralize IPU through two successive demethylation followed by a ring cleavage. Some the genes coding the enzymes involved in different steps of isoproturon degradation have also been identified and characterized. Based on the findings of this study, it might be concluded that bacteria might serve as potential candidates for devising the strategies for bioremediation of the soils contaminated with IPU.

**Key Words:** Isoproturon; Mineralization; Soils; Bacteria; Metabolites; Genes
PLANTS AND MICROBES – AN OVERVIEW OF BENEFICIAL MICROBES ASSOCIATED WITH PLANTS

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Green revolution lead the world towards high crop yield without increase in cultivated land area. It introduced the change from conventional to modern agriculture methods. Organic/farmyard manures were replaced with chemical fertilizers and pesticides were used to get rid of plant pathogens. However, for last two decades, environmentalists are concerned about the use of chemicals and urging for their replacement. Microbes have solution of this problem. These are associated with plant parts such as root, shoot, leaves and soil around the roots. Plant associated microbes include bacteria, viruses, fungi, and protozoa. They are responsible for plants health and diseases. These microbes promote plants growth through different mechanisms including nitrogen fixation, phyto-hormones production, and nutrients solubilization (phosphorous, potassium, zinc), etc. Pathogenic microbes attack plants and reduce the crop yields, however, beneficial microbes enhance plant immunity through increased level of jasmonic acid and other hormones involve in defense system. These microbes also kill the pathogenic one by HCN, siderophore, bacteriocin and extracellular enzymes production. An overview of these microbes and mechanisms involve in plant growth promotion will be given. In addition, use of “Bioformulations” for plant disease control and growth promotion will also be discussed briefly.

Key words: Bioformulations, plant growth promoting bacteria, pathogenic microbes
Soil salinity is a global problem in which salts progressively accumulated in the soil. Due to these accumulated salts, crop productivity, microbial community and agricultural economics affected greatly. Salinization destroys all vegetation and other organisms living in the soil and thus it is injurious to the environmental health. A significant proportion of cultivated land is salt-affected, currently out of 230 million ha of irrigated land, 45 million ha is salt-affected whereas 32 million ha is salt-affected to varying degrees. Salinity tolerance is quite a complex mechanism in plants. Plants have adapted several mechanisms to cope with the stressed conditions. Cochlearia x hollondica (Ch) is a halophyte growing naturally on the coastal area of The Netherlands. In this species SOS1 is highly salt inducible gene which plays important role in the higher salt tolerance of this species.

ChSOS1 was expressed in Arabidopsis thaliana (Col) sos1 mutant background under its native and a constitutive promoter (35S CMV). ChSOS1 expression (in T2 lines) not only complement the mutant but the expression is many folds higher as compared to wild type A. thaliana and C. x hollandica. Tolerance index was significantly higher in the complemented lines. Sodium content reduced significantly in shoot and root in the complemented lines however, potassium content was comparable to the A. thaliana wild-type, thus reduced the hypersensitivity of the mutant. C. x hollandica SOS1 promoter is much stronger which induce the gene under salt stress and enhances the tolerance of A. thaliana sos1 mutant for salinity. Such mechanisms can be engineered to important agronomic crops to enhance their tolerance against biotic stress like salinity.

Key words: Soil Salinity, Halophytes, Tolerance, Gene Expression, Complementation
Oral Presentations
IMPACT OF IRRIGATION WITH WASTEWATER ON ACCUMULATION OF HEAVY METALS IN SOIL AND VEGETABLES IN GUJRAT PAKISTAN

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Heavy metals are considered as serious environmental threat on various countries. One of the countries like Pakistan is also facing the problem of heavy metals especially in Gujrat city of Punjab, Pakistan. Evenly, vegetables are growing with the help of waste water in agriculture sector of Gujrat. This type of water contains various types of metals which are very toxic such as cadmium (Cd), lead (Pb), copper (Cu) and zinc (Zn). It may cause many hazards on human health in the area of Gujrat. The physiochemical factors determined for the samples like organic matter, organic carbon, electrical conductivity and pH. These factors which transfer from soil to plants were analyzed with the help of samples. Irrigated soil can be polluted with Cd (4.2mg/kg), Pb (12.4mg/kg), Cu (41mg/kg) and Zn (28 mg/kg). These heavy metals daily intake and exceed from the limits. Health Risk Index diverse from 0.003 for Cd, 0.006 for Pb, 0.05 for Cu and 0.32 for Zn; Pb and Zn representative a possible health risk. Our results show that from heavy metals vegetables are polluted in our area and cause numerous health risks to the animal populations and human health. Therefore, protective methods can be used to decrease heavy metals pollution. Government should also take the reaction for the heavy metals to protect soil, animal and human health in the city of Gujrat.

Key Words: Health risk, Daily intake, Vegetables, Agricultural soil, Waste water and Heavy metals.
Conventional agricultural practices result in soil deprivation through loss of soil organic carbon. Biochar amended soils have multiple environmental benefits, including improvement in soil physicochemical properties, reduction in leaching losses of essential nutrients and improves the soil biological characteristics. A two-year field experiment was performed to evaluate the direct and residual effect of biochar in combination of N fertilizer on carbon fractions in wheat-maize cropping system of arid region of Pakistan. Biochar (sugarcane straw) prepared by conventional pyrolysis, having seven treatments in present experiment B0N0=control (no biochar and N fertilizer), B1N0=0.5% biochar C ha\(^{-1}\), B2N0=1% biochar C ha\(^{-1}\), B0N1= recommended N fertilizer (100 kg ha\(^{-1}\)), B1N1=0.5% biochar C ha\(^{-1}\)+ recommended N fertilizer, B2N1=1% biochar C ha\(^{-1}\)+ recommended N fertilizer. The biochar was applied before the sowing of wheat (first crop) and residual effect was studied on the maize crop. The results showed that biochar amendment increased soil pH, soil organic carbon (SOC), other carbon fractions (dissolved organic carbon, labile organic carbon, hot water extractable carbon and HCl insoluble carbon). However, water soluble carbon and soil bulk density was gradually decreased during the both growing cycles. The soil organic carbon (SOC) distinctly boosted with increasing biochar rate over the course of the experiment suggesting that biochar application has great potential for carbon sequestration in the arid soil. The findings therefore also propose that incorporation of inorganic fertilizer-N in combination with biochar could have significant effect on biological properties (microbe’s activity). The outcomes suggest that biochar amendment to carbon depleted soils had an appropriate management practice to enhance soil carbon storage.

KEYWORDS: Residual effect, Biochar, Carbon fractions, Biological properties

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Continuous, historical and precise information on the evolution of land use and land cover (LULC) on the Earth’s surface is very significant for any type of sustainable development program, in which LULC is one of the most the main selection criteria. In this study, a supervised classification was functional to three Landsat images collected over time (2000 and 2019) providing fresh and historical LULC conditions for the Peshawar District. The outcomes of the supervised classification were further enhanced using image enhancement and visual clarification. Visual interpretation was not only beneficial for increasing the accuracy of Landsat images classification, but also for identifying areas of efficient water use for irrigation and private land reclamation areas. Five classes of LULC have been identified and mapped. Subsequent comparisons to the classification of classified images designated that the main change was from Urban expansion to Agriculture and barren soil. In 2008 the urban land cover was examined as 96 km² with 7.48%, with the changing of time urban land was disburse during last 19 year in 2019 it was noted as 350 km² with percentage of 27. Agriculture land was found 499 km² in 2000, and in 2019 it was examined as 388 km², barren soil was decrease from 2000-19 up to 12 %. Other land cover class such as rocky area also has little undergone changes. Based on the identified causes of these changes, we formulated policy recommendations for better management of LULC.

Key Words: Change detection, Remote sensing, Image processing, GIS, Remote Sensing
SORPTION POTENTIAL OF VARIOUS BIOSORBENTS FOR ARSENIC REMOVAL IN AQUEOUS SOLUTIONS

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We explored the efficiency of various biosorbents (egg shell, java plum seed, water chestnut shell, corn cob, tea waste and pomegranate peel) for arsenate (As(V)) and arsenite (As(III)) removal from contaminated water. Significantly, egg shell and java plum seed displayed the highest As(III) removal (78-87%) at pH 7 followed by water chestnut shell (75%), corn cob (67%), tea waste (74%) and pomegranate peel (65%). In contrast, 71% and 67% of As(V) was removed at pH 4.1 and 5.3 by egg shell and java plum seed, respectively. The 1 g L−1 biosorbent dose yielded the maximum As(V/III) sorption by all the biosorbents, notably for egg shell and java plum seed, after 2 h contact time. Langmuir isotherm and pseudo-second order kinetic models were found to be the best to explain As(V) and As(III) sorption. Surface functional groups such as –OH, –COOH, –NH2 and sulfur-bearing moieties were possibly involved for As uptake on biosorbent surface from solutions. The SEM-EDX analysis showed that heterogeneous surface of biosorbents, possessing rough and irregular areas, could have led to As(V) or As(III) sorption. Both As(V) and As(III) were successfully desorbed (up to 97%) from the biosorbents up to four sorption/desorption cycles. Our study highlights that, egg shell and java plum seed have the greatest ability to remove As(III) and As(V) from As-contaminated water. The findings of this pilot scale research advance our understanding on the removal of As by biosorbents in water, which is crucially-important before large-scale implementation of the suitable environmental remediation technology.

Key Words: Arsenic contamination; Biowaste; Drinking water; Pollution abatement
INDUCTION OF ARSENIC STRESS TOLERANCE IN CAPSICUM ANNUM THROUGH *Trichoderma Harzianum* SAND MIX METHOD

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The research was performed at Nusrat Jahan College Rabwah Pakistan to overcome arsenic stress in two varieties “Sanam and Ghotki” of *Capsicum annum* through *Trichoderma harzianum* sand mix method. Seeds of mentioned chili varieties and *Trichoderma* fungus were taken from NARC, Pakistan. Cups of sand were mixed with *Trichoderma harzianum* at the rate of 2x10⁷ CFU. Chili seeds after surface sterilization through mercuric chloride were sown in cups of fungal treated sand. Arsenic oxide (As1: 1 mg/L and As2: 2 mg/L) stress was applied after one week of sowing. Seedlings were harvested after 30 days of sowing and were preserved in 50 mM potassium phosphate buffer. Roots and shoots were separately preserved. The preserved samples were subjected to different biochemical tests. This study revealed *Trichoderma* sand mix method very effective method to eliminate Arsenic oxide stress by generating ROS damaging proteins.

**Key Words:** green chilies, arsenic, *Trichoderma harzianum*, seedlings, sand mix.
CHARACTERIZATION AND RECYCLING OF ORGANIC WASTE AS SUSTAINABLE FERTILIZER FOR SOIL AMMENDMENT

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The characterization and recycling of organic waste for the application of fertilizer, is important for sustainable nutrient management. The present study aims to present information regarding bioavailability of nutrients to maize crop from soils amended with different waste materials using the Hadley sequential fractionation method. Waste materials from four different sources, including animal waste fresh (AWF), animal waste compost (AWC), mixed waste fresh (MWF), and mixed waste compost (MWC) were selected to determine the different fractions of total, extractable and water soluble heavy metals (Fe, Zn, Ni, Mn, and Hg), phosphorus and nutritious elements (K, Ca, and Mg). The phosphorus was stepwise fractionated into water soluble extracted P (H₂O-P), plant available (NaHCO₃-P), Al associates (NaOH-P), Ca associated (HCl-P) residual forms. The overall P fractions extracted varied in order of HCl > NaOH > NaHCO₃ > H₂O while the nutrients concentration varied as Mg > K > Ca. The highest P content was found in AWF whereas minimum was observed in MWF. Analytical results indicated that composting of animal manures enhanced P availability and improved plant nutrition. The use of composted animal manures as soil amendment could be economically productive and would potentially ameliorate the major concerns associated with organic waste.

Key Words: Animal Manure, Mixed Waste, Phosphorus, Soil, Sustainability
Mining industry involves the production of waste containing toxic metal ions like cadmium (Cd) and a characteristic very low pH (2.3-5) which causes environmental problems worldwide. A submerged aquatic macrophyte *Elodea canadensis* is able to change the surrounding water pH, and by that, influence the metal uptake. The current work was aimed to understand the mechanism behind pH-change by *E. canadensis* and to optimize its use for phytofiltration. The pH changes in the surrounding nutrient solution by *Elodea* shoots were investigated after cultivation of various plant densities in hydroponics at a starting pH of 4.0 and in the presence of different Cd concentrations. *E. canadensis* shoots were also grown under light, darkness, and in the presence of a photosynthetic inhibitor (DCMU) and 0.5 µM Cd in the solution. Results revealed that *Elodea* had a strong ability to increase the surrounding water pH, when the initial pH was low, which resulted in increased accumulation of Cd. The higher the Cd concentration, the more pronounced was the pH change. The pH rise was found to be more pronounced under darkness and in the presence of photosynthetic inhibitor (DCMU). Our current fluorescent microscopy work with *Elodea*’s protoplasts corroborates this but still needs more experimental proof. Understanding such plant-induced pH-rise and its mechanism in plants exposed to metal stress may provide an effective approach for illustrating fundamental aspects of plant stress physiology, and optimizing strategies for handling of water pollution, as well as crop establishment under stress conditions.

**Key Words:** Cadmium, *Elodea canadensis*, pH-rise, photosynthesis, light reaction, plant stress physiology.
The current study was focused to monitor the sedimentary P cycling mechanism and biogeochemical characteristics in the diverse Goi-NaIa catchment of River Jhelum, Azad Jammu and Kashmir (AJ&K). We selected 7 monitoring stations in the month of June 2018 at sub-catchments scale and delineation was carried out by using GIS terrain analysis tools on the basis of elevation, slope and topography. The monitoring station include: (1) Dominated natural vegetation sub-catchment at the start of catchment which will serve as control; (2) highly anthropic point after the Rawalakot city; (3) highly polluted area of city waste dumping site; (4) mixed anthropic and agricultural site; (5) diffuse nutrient sources including human settlements; (6) monitoring station where poultry production and diffuse sources and; (7) catchment outlet with all mixed sources. The time integrated sediment samples were installed during second week of June 2018 and three sampling intervals (summer-July, autumn-September and December-fall in 2018) has been carried out. The results regarding the seasons (S), location (L) and their interaction i.e., S × L upon different basic sediment characteristics (TOC, TN, different P fractions, P bioavailability and overall P dynamics have shown statistically the significant difference (p ≤ 0.05) except particle size distribution. Results showed that TP contents when ranked have shown a pattern from highest to lowest for seasonality as; summer (1657.9 mg kg⁻¹) > autumn (1619.5 mg kg⁻¹) > autumn (1387.4 mg kg⁻¹). The overall soil TP contents for land use followed the pattern from highest to lowest as; anthropic (2352.2 mg kg⁻¹) > waste dumping (2296 mg kg⁻¹) > agriculture (1540.7 mg kg⁻¹) > D1(1320.6 mg kg⁻¹) > D2(1299.4 mg kg⁻¹) > outlet (1282.8 mg kg⁻¹) > forest (792.7 mg kg⁻¹). Similarly, the overall inorganic P (Pᵢₙ) the values for seasonality were as; summer (1535.8 mg kg⁻¹) > autumn (1507.8 mg kg⁻¹) > fall (1328.4 mg kg⁻¹). The overall sediments Pᵢₙ content for locations followed the pattern from highest to lowest were similar to that of TP and it follows as; anthropic (2183.4 mg kg⁻¹) > waste dumping (2172.4 mg kg⁻¹) > agriculture (1467.2 mg kg⁻¹) > D1(1233.3 mg kg⁻¹) > D2(1221.7 mg kg⁻¹) > outlet (1186.1 mg kg⁻¹) > forest (737.1 mg kg⁻¹). Individually, the anthropic and city waste dumping site sediments showed highest concentrations of Pᵢₙ during summer and autumn seasons, respectively. The organic P (Pₒₚ) in sediments when ranked showed a pattern from highest to lowest and the values for seasonality were; summer (122.01 mg kg⁻¹) > autumn (111.71 mg kg⁻¹) > fall (58.99 mg kg⁻¹). The overall sediments Pₒₚ content for locations followed the pattern from highest to lowest as; anthropic (168.82 mg kg⁻¹) > waste dumping (123.58 mg kg⁻¹) > outlet (96.10 mg kg⁻¹) > D1(87.34 mg kg⁻¹) > D2(77.71 mg kg⁻¹) > agriculture (73.46 mg kg⁻¹) > forest (55.60 mg kg⁻¹). Individually, the anthropic and city waste dumping site sediments showed highest concentrations of Pₒₚ during summer and autumn seasons, respectively. The Ca-associated P showed the highest (%P) share in the total P as well as inorganic P. The sediment bioavailable P (anion exchange resin extractable P) content when ranked highest in sediments from waste dumping site (53.34 mg kg⁻¹) ≥ anthropic (50.12 mg kg⁻¹) ≥ agriculture (29.36 mg kg⁻¹) ≥ D1(27.47 mg kg⁻¹) ≥ D2(21.51 mg kg⁻¹) > outlet (17.88 mg kg⁻¹) > forest (3.75 mg kg⁻¹). Individually, higher bioavailable P was noted in anthropic sediments followed by the waste dumping site during summer.

**Keywords:** Phosphorus fractions; Ecological risk; Sediment, Kashmir
**ICSS/IAGC/2019/OP/20**

**CO-PRECIPITATION PREPARED CALCIUM DOPED NICKEL FERRITE NANOPARTICLES HAS CAPACITY TO BREVICORYNE BRASSICAE PROLIFERATIONS ON BRASSICA NAPUS IN EFFECTIVE MANNER**

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Canola (Brassica napus) is the third most important source of edible oil. In Pakistan and other countries, losses due to Brevicoryne brassicae has been reported up to 75% with major reductions in oil quantity and quality. For its management, conventional chemical insecticides have lost efficacy and newer ones cannot be permitted easily as this insect attacks on or during pod formations, so trans-podal contaminations of oil seeds can lead to serious hazards for edible oil consumers later on. Therefore, the present study was designed to incorporate co-precipitation prepared calcium doped nickel ferrite nanoparticles with generalized formulation used were A+2Fe3+2 O4, with Ni1-xCaxFe2O4 (with x 0.0 till1.0). Nickel ferrite is one of the lax ferrite material owing to its little conductivity and high electrochemical stability. The nickel ferrite properties are, to a countless degree, working in technological claims, counting telecommunication, electronic device and transformer cores etc. Its application in nano-pesticides is totally new. Ongoing research has shown significant improvements in this pest control when subjected under calcium doped nickel ferrite nanoparticles application. Further investigations are underway for impacts on plants and oil yield.

**Key Words:** Nanomaterials, trace elements, biomaterials, insects, plants
ARSENIC RETENTION IN CONTAMINATED SOILS IN RESPONSE TO BIOCHAR AMENDMENT

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The arsenic contamination in groundwater and soil has caused serious hazards to ecosystem and food chain. In this study, a pot trial was conducted on target plant wheat to check the effect and uptake of arsenic (at two concentrations i.e. As 1 and As 2) from synthetic irrigation water with amendment of biochars pyrolysed from feedstocks namely, rice husk and biowaste biochar at 550°C. Two different biochars levels (10 and 20 t ha⁻¹) were applied. A total of 15 treatments (45 pots) were set in the bioassay/pot trial. Different characterization techniques like scanning electron microscopy (SEM), X-ray photoelectron spectroscopy (XPS), Fourier transform infrared spectroscopy (FTIR), and different physico chemical parameters were done over water, soil and biochar samples. Plant biowaste biochar proved better immobilizer of As at high level (As 2) of its application while rice husk biochar worked well at lower level (As 1) in trial. However, wheat plant showed no physical symptoms of toxicity at both levels of As application. Biowaste biochar characterization showed more nutrient content and carbon than rice husk biochar, so having more potential for sustainable soil health and plant growth.

Keywords: Arsenic, Biochar, contamination
EFFECT OF POST HARVEST MANAGEMENT PRACTICES ON THE THERMODYNAMICS OF IRON MINERALS IN RICE CULTURE: PHREEQC MODELING

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Proper management of post-harvest crop residues is essential for environmental sustainability and continuity of crop cultivation. After implementing the ban on burning of crop residues in many countries due to environmental degradation, the crop residues are frequently incorporated in soils. However, how does this later practice affect the geochemical processes during rice production is not exactly known yet. The objective of this study was to analyze the effects of two different post-harvest management practices (burning and incorporation) on the thermodynamics of iron minerals during vegetative phase of rice production. Two rice plots, one with burnt crop residues (R 178) and other with incorporation of crop residues (R 179), were selected. Modified lysometers were installed to collect the soil solution (SS) samples and solutions from surface layer (LS) were collected directly. Measurements of some modifiable parameters (pH, EC, Eh, Fe²⁺ etc.) were carried out in situ. Concentrations of anions and cations were determined through ion chromatography and inductively coupled plasma atomic emission spectroscopy. Alkalinity was determined using Gran function. PHREEQC modeling was used to determine the evolution of indexes of saturations of several iron minerals in SS and LS during a complete day. The results showed that SS of both plots (R 178 and R 179) were over-saturated with respect to goethite, hematite, siderite and fougerite while under-saturated with respect to melanterite, jarosite-K and near to equilibrium for Fe(OH)₃. The LS of both plots, in contrary to SS, were oversaturated with respect to Fe(OH)₃ while under-saturated with respect to siderite. The incorporation of rice residuals resulted in smaller SI of goethite, Fe(OH)₃, hematite, jarosite-K and fougerite while slightly larger SI of siderite and melanterite in R 179 as compared to R 178. So, incorporation of residues affect the dissoulation/precipitation of iron minerals.

Key Words: rice cultivation, crop residues, redox conditions, geochemistry
BIOCHAR AND LEGUME RESIDUES IMPACT ON WHEAT POST-HARVEST SOIL PROPERTIES

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A field experiment was executed at the research farm of The University of Agriculture Peshawar to find biochar and legume residues impact on wheat post-harvest soil properties. The proposed design used for the experiment was randomized complete block design having three levels (0, 5 and 10 t ha⁻¹) of biochar and four different legume residues (fallow, cowpea, mung bean and sesbania) were used in the experiment. The results revealed that maximum soil pH, organic matter, total nitrogen, AB-DTPA extractable P, K, Zn, Cu, Mn, Fe, saturation percentage, moisture content and minimum bulk density was recorded with the incorporation of biochar at the rate of 10 t ha⁻¹. Soil EC was non-significantly affected by biochar application at different ratios. Among legume residues maximum organic matter, total soil nitrogen, AB-DTPA extractable K, P, Zn, Fe, Mn, saturation percentage, moisture content and minimum bulk density was recorded with the incorporation of sesbania as legume residues. Soil Cu, pH and EC was non-significantly affected by differences among legume residues. The biochar and legume residues interactive effect was found significant for total soil N, AB-DTPA extractable P, K, organic matter, bulk density, moisture content and saturation percentage while other parameters were found non-significantly affected. From the results it was concluded that application of biochar along with sesbania residues should be incorporated to increase the fertility status of soils and improves the fertility status of soils.

**Key Words:** Soil properties; Biochar; Legume residues; Sesbania; Cowpea; Mung bean
CHEMICAL AND BIOLOGICAL DEGRADATION OF BIOCHARS DEPEND ON BIOCHARS’ CHEMISTRY AND TEMPERATURE UNDER LABORATORY CONDITIONS

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Biochar is a carbon (C) rich material produced from pyrolysis of biomass under no or limited supply of oxygen, resistant to decomposition due to recalcitrant nature and encourages long-term C sequestration in agroecosystems. Biochar can be produced from a wide variety of feedstocks ranging from crop residues, wood chips and organic waste. Physico-chemical characteristics of biochar amendments strongly depend on the pyrolysis temperature and duration. Application of biochar to soil offers numerous benefits to soil-plant systems by improving soil nutrient retention, increasing soil water holding capacities, reducing soil nitrous oxide (N\textsubscript{2}O) and methane (CH\textsubscript{4}) emissions, sustaining soil microbial activity, and ultimately enhancing soil fertility and plant productivity. After application, biochar undergoes physical, chemical and biological degradation in soil and chemical (abiotic) mineralization can be equal to biological (biotic) mineralization. We performed abiotic and biotic mineralization assay of low-pyrolysis-temperature biochar developed from eucalyptus leaves biochar (ELB), wheat straw biochar (WSB), poultry manure biochar (PMB), cotton sticks biochar (CSB), vegetable waste biochar (VWB), lawn grass biochar (LGB) and citrus leaves biochar (CLB) at 15, 30 and 45 °C temperatures. Our results demonstrated that abiotic and biotic mineralization rates were feedstock and temperature dependent. Ratios between biotic to abiotic mineralization significantly varied with temperature and feedstock. We also observed strong positive relationships of abiotic and biotic mineralization with volatile matter, labile carbon, pH and total phenolics contents of biochar amendments.

Key Words: Biochar, Chemical and biological C mineralization, Temperature, Biochar surface chemistry
STRATEGIC ENVIRONMENTAL ASSESSMENT AS A TOOL FOR TRANS-BOUNDARY RIVER BASIN MANAGEMENT: A CASE STUDY OF THE CHENAB RIVER BASIN

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Strategic Environmental Assessment (SEA) role is not limited to any sector but its role expending in all developing projects, plans and programmes. The study investigates the role of SEA in the Mekong and Mara river basins’ planning and its compatibility for the Chenab River Basin (CRB). The study first investigates two international SEA case studies (Mekong and Mara River Basins) based on literature review and selected interviews and tries to identify the success conditions for these SEA studies. The source of data for the CRB situation was based on structured and semi-structured interviews with key stakeholders in Pakistan. The study shows that the major success conditions for the SEA study of the Mekong River Basin included Mekong River Agreement of 1995. Similarly, the key success conditions for the SEA study of the Mara River Basin included the East African Community agreement of 1999, and also documented possible success conditions for the SEA study of the CRB included the Indus Water Treaty of 1960. It is concluded that although the SEA as assessment tool provided interesting contributions for the Mekong and Mara river management, the level of success was limited because the recommendations were not accepted or partially implemented. Although, the CRB complies most of success factors and conditions of successful SEA study, those which were recorded in the Mekong and Mara case studies except the level of cooperation between India and Pakistan is limited and Indus Water Treaty of 1960 is missing in environmental and joint management approach.

Key words: Strategic Environmental Assessment, Chenab River Basin, Water Policy
SURFACE MODIFICATION OF COCONUT COIR BASED GRANULAR ACTIVATED CARBON (GAC) FOR ENHANCEMENT OF TEXTILE DYE ADSORPTION

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In Pakistan the control of textile wastewater pollution has been remained a challenging task, therefore there is need to develop low cost treatment option for textile dyes removal. Adsorption techniques are widely used to remove textile dyes, but the use of commercial activated carbon as adsorbent material is restricted due to its high cost. Therefore, adsorption of textile dyes on surface modified agricultural waste such as Coconut Coir can be a promising treatment option for this purpose. The present research work focused on the surface modification of Coconut Coir by physico-chemical processes to obtain an adsorbent material i.e. granular activated carbon for Methylene Blue (MB) dye removal. The effects of different physico-chemical processes such as particle size distribution, impregnation material, carbonization temperature and time and activation agent on adsorption process have been investigated using batch reactor. The physico-chemical characterization such as particle size, carbon yield%, impregnation ratio, bulk density, zero-point charge (pH\text{zpc}) and proximate analysis confirmed the suitable application of this surface modified adsorbent material for textile dye removal. The maximum adsorptive removal (96 mg/g) of MB dye was obtained in these experimental conditions. A high adsorption efficiency (98-100%) was achieved by the obtained adsorbent material at an effective range of pH (6-10). The adsorption capacity of the surface modified Coconut Coir has been compared with that of the unmodified Coconut Coir waste. The results indicate that such surface modified agri-waste materials could be employed as low cost alternatives to commercial activated carbon in wastewater treatment for the removal of colour and textile dyes.

Keywords: Agri-waste, Surface modification, Granular Activated Carbon, Textile dyes, Adsorption
PURIFICATION OF CANAL WATER USING DIFFERENT TEXTILE FABRICS

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According to Pakistan Council of Research in Water Resources (PCRWR) Pakistan is facing shortage of water. There is not much time left when Pakistan will be out of drinking water. Many fresh water sources like rivers, canals are left unused just because of the total suspended solids (TSS). If we can just decrease the TSS of canal water up to the National Environmental Quality Standards (NEQS). We can purify many new drinking water resources for local people of backward areas. This present study was fully focused on developing an efficient, cost effective model using different textile fabrics for treatment of TSS from canal water. The clothes were cotton, silk, nylon, danier and polyester. The result showed upto 85% reduction in TSS. Which was up to the NEQS. This study can save people of backward areas form many drinking water diseases like cholera, Typhoid etc. This product is commercially valuable at the same time it would minimize the cost of water treatment. Further result showed clothes were easily available and effective than any other treatment.

Keywords: Water Purification, TSS, Textile fabrics
IMPACT OF BIOCHAR AMENDMENT AND NITROGEN FERTILIZATION ON GREENHOUSE GASES EMISSION FROM PADDY RICE

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Synthetic fertilizers are major drivers for inducing nitrous oxide (N\(_2\)O) emissions, and rice’s fields are primary source of methane (CH\(_4\)) fluxes. So an attempt in current study was made to mitigate these greenhouse gases (GHGs) by biochar amendments and N fertilization in paddy rice under a controlled condition. In this study, 0, 2 and 4% (abbreviated as WBC, 2BC and 4BC, respectively) biochar were mixed in 3500 gm unsterile soil along with 0, 70 and 140 kg N ha\(^{-1}\) (abbreviated as N\(_0\), N\(_{70}\) and N\(_{140}\), respectively) before transplanting of rice seedlings. Each treatment was repeated three times in a completely randomized design (CRD). The results showed that mean CH\(_4\)-C fluxes were ranged 1.21 to 1.28 µg CH\(_4\)-C cm\(^{-2}\) d\(^{-1}\) from 2BC and 4BC, respectively. Additionally, 2BC and 4BC along with 70 kg N ha\(^{-1}\) induced 112-132% and 35-40% higher CH\(_4\)-C emission rate over control and N\(_{70}\) treatments, respectively. However, application of 2BC and 4BC along with 140 kg N ha\(^{-1}\) induced 16-24% high CH\(_4\)-C emission over N\(_{140}\) treatments. The N-alone accelerated 67-164% higher mean N\(_2\)O-N emission rate over control. The N\(_2\)O-N emission were ranged 0.13 to 0.17 µg N\(_2\)O-N cm\(^{-2}\) d\(^{-1}\) from pots treated with 4BC and 2BC, respectively; interestingly N\(_2\)O-N emission from 4BC was 18% low as compared to control treatment. In conclusion, biochar addition could reduce the N\(_2\)O emission even under higher N fertilization.

**Key words:** Synthetic fertilizers; nitrous oxide; methane; paddy rice
LINKAGES OF LAND RIGHTS AND SOIL CONSERVATION INVESTMENTS FOR SUSTAINABLE ENVIRONMENT

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Agricultural land being fixed in nature is perhaps the key factor of production that stimulate agricultural investments. Series of policies for land use right and transfer have been formulated as this issue is now at global level with various dynamics depending on individual country’s land tenure arrangements. Sustainable agriculture lies on three major principles that are economic returns, environmental concern and economic equity. Being an agriculture-based economy of Pakistan, sustainable agriculture production is desirable for feeding a huge bulk of population. It has become more crucial in the face of rapid degradation of natural resources like soil erosion, water and soil quality in terms of nutrients. In Pakistan, land is the major source of earning, but it is suffering with unequal land distribution and rapid degradation. This study estimated the impact of land rights on soil conservation measures by employing Endogenous Switching Regression (ESR). Data were collected from 340 rural households from Punjab Province of Pakistan. Findings confirmed the importance of secure land rights in facilitating long-term soil-improving investment. One of the policy implications suggest reforms for land rights in enhancing investment in soil-improving or conservation measures.

Key Words: Land Rights, Soil Conservation Investments, Sustainable Environment, Pakistan
SOIL ORGANIC MATTER CYCLING IN RESPONSE TO BIOCHAR AND ITS FEEDSTOCK ADDITION UNDER DIFFERENT WATER AVAILABILITY

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Soil organic carbon (SOC) is critical for soil health and sustainable agriculture. It has also been proposed as a strong sink of atmospheric CO₂ to mitigate climate change. A change in its cycling in response to abiotic and biotic changes may entail changes in soil health. Biochar is a C rich carbonaceous material prepared by the pyrolysis of organic feedstocks under oxygen limited conditions. It has been proved to improve the soil functions. On the other hand, crop residues are cost-efficient way to maintain soil’s function. Studies on comparison of the effectiveness of a biochar and its feedstock material in maintaining soil health indicators under varying moisture conditions are rare. Therefore, we designed a study to evaluate the effectiveness of a biochar (corn-cob derived) and its feedstock to influence soil health indicators at moisture levels i.e. 30 & 60% moisture at water holding capacity (WHC). Moreover, a soil organic carbon (SOC) poor (~0.7% SOC) and an SOC rich (~1.6% SOC) were included in the experiment to determine the influence of initial C content on this interaction. In both the soils, feedstock induced higher soil respiration than biochar at both moisture levels. However, in C poor soil, the soil respiration in response to feedstock addition was significantly higher at 30% WHC than at 60% WHC. The biochar induced similar soil respiration at both moisture levels, which was significantly higher than the controls, in both the soils. Apparently, at this stage of the experiment, it can be said that feedstock it better at maintaining soil health functions than the biochar derived from it. However, the complete picture will be clear when the remaining data on other soil variables will be available.

Key Words: Soil organic C cycling, Water holding capacity, Soil health indicator, Comparison of biochar and feedstock, Soil respiration
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ANALYSIS OF SEASONAL PATTERN OF NO₂ DISTRIBUTION OVER PAKISTAN BY USING SATELLITE OBSERVATIONS

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The present study was conducted to spatially analyze the seasonal pattern of nitrogen dioxide distribution over Pakistan. Concentrations of the NO₂ during the period 2005 to 2009 (for the months of January, April, July and October) were obtained from the OMI satellite archives under the TEMIS project. The data sets of variable temperature of months January, April, July, October 2005-2009 proved to be normally distributed. The value of correlation coefficient (r) was greater than the critical value at significance level α= .01 except for the month of October-2005 with lower value than the critical value at α= .01 significance level. Precipitation variable datasets for the months of January, April, July and October 2005-2009 was not proved to be normally distributed as correlation coefficient (r) was lower than the critical value at significance level α= .01 except for the month of January-2005, January and July 2009. This study concluded that there was no correlation between nitrogen dioxide concentrations and temperature and precipitation/rainfall over Pakistan. A very little nitrogen dioxide is produced in Pakistan. Most of the nitrogen dioxide found tropospherically distributed over Pakistan came from India.

Key Words: NO₂ analysis, air pollution, NO₂ in Pakistan, NO₂ concentration
QUANTIFICATION OF CARBON STORAGE POTENTIAL OF CITRUS BASED AGROFORESTRY SYSTEM IN SARGODHA, PAKISTAN

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Continuous rise in CO2 emissions during the last five decades results in severe global warming and climate change. This biomass-based study was designed to analyze the carbon incorporation in citrus (Citrus reticulate Blanco.) based agroforestry system in four subdivisions (tehsils) of district Sargodha. The total carbon content of tree aged 15 years was determined through nondestructive approach whereas soil sampling was done at two depths: 0-15 cm and 15-30 cm to calculate the soil organic carbon (SOC). The maximum total tree carbon stock ha-1 (2.48 Mgha-1) and total tree CO2 sequestration ha-1 (9.21 Mgha-1) was estimated in tehsil Bhalwal with mean values of 1.13 Mgha-1 and 4.13 Mgha-1 respectively, whereas, the minimum total tree carbon stock ha-1 and CO2 sequestration ha-1 (0.93 Mgha-1 and 3.40 Mgha-1) was calculated in tehsil Silanwali. Soil organic stock decreased with the increase of depth and ranged from 15.12 Mgha-1 to 19.51 Mgha-1 with maximum value for tehsil Shahpur and minimum for tehsil Kot Momin. The above results indicated that the citrus based agroforestry system can play an important role in capturing CO2 to mitigate the current climatic changes.

Key Words: Quantification, Citrus, Carbon stock, Biomass, Soil Carbon
DEVELOPMENT OF AGRICULTURE SECTOR THROUGH GROUND WATER USING GIS AND REMOTE SENSING A CASE STUDY OF DISTRICT MALAKAND KP, PAKISTAN

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The accessible surface water resources are insufficient to meet all the water requirements for drinking, irrigation and industrialization purposes; therefore, the demand for groundwater has increased day by day. Integration of remote sensing data and the geographical information system (GIS) for the Exploration of groundwater resources has become a breakthrough in the field of groundwater research, which assists in assessing, monitoring, and conserving groundwater resources. The study is an effort to identify the groundwater potential zones for agriculture sector development in study area. ArcGIS 10.4 was utilized for geospatial analysis. The methodology implemented is referred as Multi Influencing Factor (MIF) techniques. This method is widely used for identification of groundwater potential zones. Seven parameters i.e. Land use/Land cover, Geology, Soil, Rainfall, lineament Density, Drainage Density and slope were used for delineation. The groundwater potential zones were categorized into four classes very high, high, Good, and poor. From the result of classification it has been found that the area 113.10 km sq. has very high, 659.38 km sq. having high, 674.68 km sq. has good, 124.17 km sq. having poor potential of ground water. The study showed that Remote Sensing and GIS provided efficient tools for mapping promising sites for groundwater exploration.

Keywords Delineation; MIF; GWPZ; remote sensing; GIS, Groundwater
SILVER LOADED ALUMINA (Ag-Al₂O₃): AN EFFECTIVE VISIBLE LIGHT ACTIVE PHOTO CATALYST FOR AQUEOUS PHASE DEGRADATION OF METHYLENE BLUE DYE

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Visible light induced photo catalytic degradation of dyes is an inviting approach in wastewater treatment techniques. In this study, silver loaded alumina was synthesized by immobilization of Ag nanoparticles on Al₂O₃ by facile green methods using leaves aqueous extract of Azadirachta indica and characterized by various advanced techniques. The as prepared Ag-Al₂O₃ particles were tested as photo catalyst on degradation of methylene blue under visible irradiation. Ag-Al₂O₃ showed improved photo catalytic performance on photo degradation of methylene blue. Effect of various parameters like catalyst dose, stirring speed, temperature, initial concentration of dye on catalytic activity were investigated. Curve Expert computer program was used for kinetics analyses of the data according to Langmuir-Hinshelwood and Eley-Rideal mechanism. A 100 mgL⁻¹ solution (50 mL) completely degraded in 120 minutes of reaction duration at 50°C over 0.1g of Ag-Al₂O₃ as catalyst.

Key Words: Al₂O₃; Azadirachta indica; Methylene blue; Langmuir-Hinshelwood; Eley-Rideal
SYNTHESIS OF NOVEL BIOCHAR SUPPORTED ZnO NANOCOMPOSITES WITH ENHANCED REMOVAL OF TARTRAZINE DYE FROM AQUEOUS SOLUTION USING BATCH EXPERIMENTAL MODE

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Dyes being released into fresh water bodies causes aquatic pollution, posing serious threat to organism’s life. Minor quantities of toxic dyes can cause serious health issues including allergic reactions, other mutagenic diseases and also cut off the light supply and causes serious damage to aquatic fauna and flora. Removal of dyes from water by suitable technique is of great interest. In present study ZnO nanoparticles were prepared using Ficus religiosa leaves extract and then nanocomposites were prepared using wheat straw biochar for the removal of Tartrazine dye from aqueous media. Batch mode sorption experiments were performed to evaluate the effect of several parameters including pH, initial concentration, contact time and dosage rate. The optimal conditions, for dye removal, were found to be at pH (2), concentration (100 mg/L), adsorbent dose (0.1g), contact time (360 min) and low temperature (30 ºC). Maximum dye removal with native, biochar and biochar based ZnO nanocomposites was 53.67, 71.18 and 81.74 mg/g, respectively. Electrostatic attraction between adsorbate and nanocomposites was responsible for adsorption. Thermodynamic study was carried out to evaluate Gibbs free energy (ΔG⁰), enthalpy (ΔH⁰) and entropy (ΔS⁰). Experimental data was tested using simple linear regression model. Result showed that kinetic modeling of adsorption was best explained by pseudo 2nd order model and Freundlich isotherm model was fitted best to present the equilibrium modeling because of higher R² values. Biochar based nanocomposites were characterized by FT-IR, SEM/EDX and XRD.

Key Words: Sorption, ZnO nanocomposites, thermodynamic study, equilibrium models.
SURFACE MODELING INVESTIGATION OF HEAT ISLAND USING RS AND GIS TECHNIQUES

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Urban regions for the most part contain offices of training, monetary areas and wellbeing focuses. These are the essential needs of human today, subsequently the general population of rustic regions moving towards urban regions, it results quick increment in urban region populace. Urbanization is a marvels in which an expansion in a populace in urban communities and towns versus rustic territories. Because of the procedure of urbanization geological limits of urban areas are changing and regular land spread is additionally switching into developed region from green land. Change of common land spread causes numerous issues like it influences bio assorted variety, generation of farming things, soil quality and spillover. Change in LULC influence atmosphere. Structures in urban zone are principally made by cement and asphalt(black-top) which have incredible capacity to assimilate sun powered radiations. Retention of sun powered heat causes more noteworthy thermal capacity and conductivity, results in increment of temperature of urban territory when contrasted with its environment.

Keywords: Urban regions, LULC, assimilate, geological limits, sun powered heat
It has been well documented that the application of biochar to soil result in many changes in the soil physical and chemical properties. Many of these changes are found to be rate dependent. Strategies for the remediation of contaminated soil, particularly with chromium, are limited and usually very expensive. Bioremediation sometimes provides an opportunity to make contaminated soils productive hence contributing to some cost recovery of the remediation expenses. It has been found that the addition of biochar enhances the productivity also of Cr-contaminated soil. In that process the presence of organic material provides an electron source for the reduction of Cr$^{VI}$ to Cr$^{III}$, the latter Cr-form being much more benign compared to the former. This was investigated in a plant growth study under controlled conditions. Firstly, biochar rates (up to 4% (w/w) and types (4) impacts on plant productivity were investigated, secondly the impact of biochar on soil respiration, and thirdly the impact of biochar on productivity of Cr-contaminated soil will be investigated. This paper only covers the first two aspects. The rates of biochar on plant productivity were found to be highly significant, but not so the type of biochar. Soil respirations rates were found to be rate dependent, again not biochar type. Contaminating the soil with Cr$^{VI}$ significantly affected soil respiration rates while adding biochar significantly reduced that impact. This is considered very promising when improvements in productivity of Cr$^{VI}$ contaminated soil are desired for bioremediation purposes which is the topic of on-going work at FCC.

**Key Words:** Chromium contamination, productivity
IS SEWAGE WATER RESPONSIBLE FOR HEAVY METAL BUILDUP IN VEGETABLES AND FODDER?

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Heavy metals contamination is a most important environmental issue globally and it affect food security throughout the world. Prolonged use of industrial or municipal wastewater for irrigation purposes creates problem of potentially toxic elements such as lead (Pb), cadmium (Cd), nickel (Ni) and chromium (Cr) in agriculture produce in many regions of Pakistan. Excessive accumulation of these elements may not only contaminate the soil but also affect the food quality. Keeping in view this issue, present survey study has been conducted at Soil Chemistry Section, Ayub Agricultural Research Institute, Faisalabad to monitor the heavy metal status in vegetable and fodder samples grown with wastewater in urban and peri-urban areas of different districts of Punjab. Vegetables and fodder samples were collected from different districts of Punjab along with location coordinates and analyzed for potentially toxic elements using flame atomic absorption spectrophotometry. Results showed that (85%) vegetable and fodder samples were contaminated with Cr, 62% with Pb, 50% with Cd and 9% with Ni in different districts of Punjab. The order of metal content was found to be Cr>Pb>Cd>Ni in vegetable and fodder samples. Based on these results, it is concluded that continuous exposures of agriculture produce to untreated wastewater cause bioaccumulation of potentially toxic elements in plant that ultimately affect human and animal health.

Key Words: Sewage water, Toxic elements, Contamination, Crops
CULTIVATION OF VEGETABLES WITH SEWAGE WATER CAUSING HEALTH HAZARDS-SOLUTIONS OF PROBLEMS THROUGH ALTERNATE CROPS

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Sewage water has been constantly applied in some areas for agricultural production to compensate water scarcity. This issue of great importance is directly related to the health of masses and the problem is increasing day-by-day due to the shortage of canal irrigation water and now with escalated population and socio-economic growth, inadequacy of irrigation water has becoming a decisive matter. Another influential factor is that, the industrial untreated wastewater is disposed of directly into domestic sewage drains frequently which eventually cause the accumulation of toxic substances in soils or plants in the form of heavy metals (Cd, Cr, Cu, Fe, Pb, Mn, Ni, Zn) around cities especially in urban and peri-urban areas. Farmers have the opinion that wastewater is a free, low-cost and ever accessible source of water and nutrients. So keeping in view the importance of this issue, a comprehensive study was initiated to assess heavy metals in vegetables, ornamental plants and forest trees which are irrigated with sewage water and to suggest the alternate crops under sewage irrigation system. This study was initiated in 2018-2019 at Soil Chemistry Section, ISCES, ARRI, Faisalabad with the assistance of CIMMYT. The results showed that substantial amount of heavy metals (Pb, Ni and Cr) were present in vegetables and fodder samples and these samples were not fit for human and animal consumption. The data depicted that 74, 68 and 25 % vegetable and fodder samples were found contaminated with Cr, Pb, and Ni, respectively. Analysis of heavy metals (lead, cadmium, nickel, chromium, manganese and zinc) contents in 62 different plant species of floriculture (ornamental & flowering plants) showed that there was a substantial amount of all heavy metals Cr, Pb and Cd uptake. Wastewater irrigated one year old ornamental and flowering plants grown in sandy clay loam soils at Farm Area of Soil Chemistry Section revealed that 82% samples were contaminated with Cr and 100 % plants samples were contaminated with Cd. Analysis results of 8 tree plants irrigated with wastewater showed that 50 % samples were contaminated with Cr and Cd compared other metals.

Key Words: Cultivation, vegetables, sewage, heavy metals, health, hazards, alternate, Pakistan
TO STUDY THE SULPHUR STATUS OF SOILS AND OILSEED CROPS IN ALKALINE CALCAREOUS SOILS OF PUNJAB

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It is reported that oilseed crops need appropriate amount of sulphur (S) for their normal growth and oil producing amino-acids. A three-year survey study (2015-2018) was conducted at Soil Chemistry Section, Institute of Soil Chemistry & Environmental Sciences, AARI, Faisalabad, to assess sulphur status of soils and plants for the very first time in alkaline calcareous soils of Punjab under oil seed crops. The plant and soil samples were collected from cotton, maize and sunflower growing areas from Vehari, Multan and Mianwali districts. Total 142 soil and 65 plant samples were collected from different villages and analyzed for S content. District wise information showed that, 40, 54 and 48 soil samples were collected from Mianwali, Multan and Vehari Districts, respectively. All the samples were analyzed by spectrophotometric method. The results revealed that most of soil samples were sufficient in S and it ranged from 9.05 to 290 mg kg⁻¹ in Vehari, 10.31 to 19.72 mg kg⁻¹ in Multan and 10.2 to 186 mg kg⁻¹ in Mianwali districts. Plant samples of cotton, maize and sunflower leaves were also drawn from Multan and analyzed in laboratory for total S contents. The results showed that S concentration in oilseed crops ranged from 0.1 to 1.2 % on dry weight basis. From this study, it was concluded that the calcareous soils of Punjab under study were found sufficient for extractable S content which is available for plant growth, similarly S content in leaves of oilseed crops was also found sufficient which clearly indicated that S content in soil and plant are in adequate level in soils of oil seed growing areas might be due to the S content in soils and or addition through irrigation water.

Key Words: Soil, oilseed plants, Sulphur, Punjab, Pakistan
USE OF SUSPENDED AND ATTACHED GROWTH OF PSEUDOMONAS AERUGINOSA STRAIN ZM130 FOR TREATMENT OF SYNTHETIC WASTEWATER IN BATCH BIOREACTOR

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Treatment of colored wastewater is a challenge due to diverse chemical composition, high chemical strength, diversity of color and the cost associated with the treatment technologies. In the present study, an efficient dye decolorizing metal tolerant bacterial strain i.e., Pseudomonas aeruginosa strain ZM130 isolated from textile wastewater was used in a simple batch bioreactor under partially aerobic and anaerobic conditions for the treatment of synthetic wastewater containing reactive black-5 azo-dye (200 mg L⁻¹). For this purpose, attached and suspended growth of the strain P. aeruginosa strain ZM130 was maintained in each bioreactor and yeast extract was used as additional C source. It was observed that attached growth of P. aeruginosa strain ZM130 showed more promising results as compared to suspended growth. Moreover, presence of yeast extract and anaerobic conditions significantly enhanced the treatment process as compare to aerobic conditions in the absence of yeast extract. However, maximum color and COD removal was achieved in anaerobic batch bioreactor with attached growth of P. aeruginosa strain ZM130 using yeast extract as C source. Based on these findings, it can be suggested that attached growth anaerobic batch bioreactors can be used more efficiently for the treatment of colored textile wastewater using dye decolorizing bacterial strains and P. aeruginosa strain ZM130 might serve as a potential bio-resource for the biotechnologies involving textile wastewater treatment.

Key Words: Reactive black-5, suspended and attached growth, anaerobic batch bioreactor, yeast extract
EFFECT OF EXOGENOUS SULFUR AND SELENIUM SUPPLY ON YIELD AND QUALITY OF MUNG BEAN (Vigna radiata L.) UNDER DROUGHT STRESS

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Legumes, in their importance to human beings, are only second to Gramineae family. Mung bean (Vigna radiata L.) is one of the most important and extensively grown kharif pulse crop in arid and semi-arid areas of Pakistan. However, its production is always hampered by the abiotic stresses mainly drought. A field study was conducted at Farm Area of MNS-University of Agriculture, Multan to evaluate the individual and combined effect of sulfur fertilizers and selenium on yield and quality of mung bean under drought stress. The experiment was laid out in a randomized complete block design (RCBD) with three repeats. The main plot consisted of two irrigation levels (W0 = water deficit and W1 = well watered) whereas, in sub plots different levels of S and Se in sole and combined form (T1 = Control, T2 = 20 g ha⁻¹ Se, T3 = 40 g ha⁻¹ Se, T4 = 20 kg ha⁻¹ S, T5 = 40 kg ha⁻¹ S, T6 = 20 kg ha⁻¹ S + 20 g ha⁻¹ Se, T7 = 20 kg ha⁻¹ S + 40 g ha⁻¹ Se, T8 = 40 kg ha⁻¹ S + 20 g ha⁻¹ Se and T9 = 40 kg ha⁻¹ S + 40 g ha⁻¹ Se) were applied. Drought stress significantly reduced the physiological attributes (relative water content, transpiration rate, photosynthetic rate, sub stomatal conductance, WUE), antioxidant enzyme activity (POD, SOD and CAT), growth attributes (plant height, leaf area, fresh weight, dry weight) and yield attributes (no. of pods plant⁻¹, no. of seeds pod⁻¹, pod length, 1000 seed weight, seed yield plant⁻¹, biological yield). Plants treated with different levels of S and Se increased the recorded parameters, however maximum increase was recorded in plants supplemented with 40 kg ha⁻¹ S + 40 g ha⁻¹ Se. Hence, it may be concluded that combined application of S and Se can be considered as an effective approach to alleviate the harmful effects of drought stress in mung bean.

Key Words: Selenium, Sulfur, Physiological attributes, Antioxidant enzymes, Droughts stress
Dissolution Mechanisms and Kinetics of Lead Minerals in Soils

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Lead (Pb) is toxic to both man and animals, there is a considerable concern regarding Pb as a contaminant in the environment. The more important Pb minerals are galena (PbS), anglesite (PbSO₄) and cerussite (PbCO₃), respectively with 86%, 68% and 77% of Pb. Other minerals that contain Pb are linarite, pyromorphite, mimetite, vanadinite, crocoisoite and wulfenite. The objective of this short communication is to depict the solubility relationships of Pb minerals and complexes in soil environments in a meaningful way. For instance, soluble Pb added to soils reacts with clays, phosphates, sulfates, carbonates, hydroxides and OM because of which Pb solubility considerably decreased. At pH 6, Pb is either adsorbed onto clays or forms Pb carbonate. Of all the trace metals, Pb is retained by soils to the greater extent. Most studies with Pb, however, have been performed and established decreased sorption of Pb in the presence of ligands and competing ions. Lead has a strong affinity for organic ligands and formation of such complexes may greatly increase the mobility of Pb in soils.

Key Words: Equilibria, Solubility, Pb Mineralogy, Soil environments
ENHANCEMENT OF ZINC IN MUNGBEAN (Vigna radiata L.) SEEDS BY FOLIAR APPLICATION THROUGH DIFFERENT SOURCES OF ZINC

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Mungbean is an important pulse crop of Pakistan. Malnutrition has become a crucial problem worldwide. Stunted growth is increasing gradually due to micronutrient deficiency in food. Zinc has a prominent role in growth and development mechanism of living organisms. Zinc bio-fortification is an easy technique to increase zinc content in food material by using modern agriculture and nanotechnology techniques. Zinc deficiency and stunted growth in human beings can be reduced by zinc bio-fortification in mungbean pulse. Keeping in view, a field experiment had been conducted to increase the zinc content in mungbean seeds by exogenous application of zinc through different sources. Different zinc sources (zinc oxide, zinc sulfate, EDTA-zinc, zinc-lysine chelate, zinc oxide nanoparticles and zinc oxide nanoparticles with lysine) has been applied through foliar application at 0.1% zinc concentration. Partition of Zn to the different parts of mungbean (roots, stem and grains) was quantified to assess the increased accumulation in mungbean seeds and other parts of plant. Results showed that Zn contents in mungbean ranged were 15.5% higher than the control treatments where seeds were treated with 0.1% solution of zinc oxide nanoparticles. Zinc treatment with 0.1% solution of zinc oxide nanoparticles significantly improved agronomic, biochemical, water related attributes and grains Zn concentrations and yield related attributes of mungbean. However, for the achievement of maximum bio-availability of Zn from enriched seeds of mungbean with best yield, the above treatment has showed best results for combating malnutrition.

Keywords: Zinc, fortification, nanoparticles, mungbean
MICROBIAL SYNTHESIS OF NANO-FERTILIZERS: INNOVATION IN CROP STRESS AMELIORATION AND BIO FORTIFICATION OF CROPS

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Nanotechnology can play an important role for sustainable development of modern agriculture. Pakistan has an alarmingly high level of malnutrition; 24 percent of the population is undernourished. The most recent estimates by the United Nations Food and Agriculture Organization (FAO) state that 37.5 million people in Pakistan are not receiving proper nourishment. Effects of nanofertilizers on plants have been reported in different studies. But a little has been addressed on the aspect of fortification of essential micronutrients (Iron and Zinc) and salt stress amelioration in staple crops. A novel formulation of Bio-nano fertilizer was developed which had not only potential to enhance nutrient use efficiency but also reduced the issue of nutrient fixation of applied essential nutrients. Various experiments conducted in controlled and natural conditions revealed that nutrient use efficiency and micronutrient fortification by Bio-nanofertilizer is more efficient and cost effective as compared to traditional fertilizers. Also, experiments conducted to assess the effect of silicon nanoparticles on stress amelioration of rice showed significant stress amelioration in rice. Preliminary results showed that rice and maize can be fortified by novel Bio-Nano fertilizer. In future agriculture use of Bio-nano fertilizers can be used as a sustainable option to ensure not only food security but also nutrient security.

Keywords: Nano-fertilizers, Bio-fortification, crop stress
AQUIFER QUALITY, MINERAL COMPOSITION AND As TOXICITY AT WEST
BANK OF CHENAB RIVER IN PAKISTAN

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Groundwater contamination by heavy metals received considerations at each level due to their toxic effects on
public health. This study can have centered on evaluate the standard of well water in reference to serious
problems and its influence on humanoid condition and on crops in Sahiwal. Samples of water were gathered
from totally different anatomical structure of sampling space and analyzed for physical and chemical parameters
as serious metalloids like arsenic (As) and boron (B), EC, pH, total dissolved solids (TDS), turbidity, carbonates,
bicarbonates, chloride, calcium, magnesium, TDS and total hardness were analyzed in samples by standard
methods. Titrimetric method of analysis was used for carbonates, bicarbonates, chloride, calcium and
magnesium. EC, turbidity, pH and TDS were determined by digital meters. Boron was determined by
spectrophotometer and atomic absorption spectrophotometer was employed for the As analysis. The results
demonstrated that EC, pH, turbidity, TDS, chloride, calcium and total hardness of the maximum samples were
within the permissible limits of WHO guidelines and National Environmental Quality Standards (NEQS, 2010) for
drinking water by Pakistan Government. The alarming situation was observed in the case of magnesium, boron
and arsenic for most of the samples which were crossing the safe limits of WHO guidelines and National
Environmental Quality Standards (NEQS, 2010) for drinking water by Pakistan Government. The ArcGIS software
was used to prepare maps. Statistical analysis was applied for available data by using statistix v. 8.1.

Keywords: Groundwater, As, TTS, Quality, Toxicity
Poster Presentations
ENHANCEMENT OF YIELD IN DIFFERENT CUCUMBER GENOTYPES BY EXOGENOUS APPLICATION OF CHITOSAN IN DIFFERENT SOWING DATES UNDER FIELD CONDITIONS

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Heat stress is a major obstacle in cucumber production in the Punjab. To save cucumber from heat stress a study was designed to evaluate chitosan on cucumber genotypes for yield enhancement under three sowing dates. Four cucumber genotypes, two tolerant (L3466 and Desi-cucumber) and two susceptible (Suyo Long and Poinsett), screened out in the previous experiment were sown in vegetable research area of Institute of Horticultural Sciences, UAF during 2016. The first sowing was done on 15th March, followed by 1st April and 15th April, respectively with four replications. Chitosan level (200 ppm) was applied as foliar spray on 30 days’ later emergence of seedling and then two times after a week interval. During present research, summer maximum temperature recorded in May was 47.5°C, June 48°C and in July 46.1°C. Yield related attributes (number of male flowers, number of female flowers, fruit set percentage, yield per plant) were recorded. It was revealed that yield per plant was highest in L3466 (2.12 kg) and Desi-cucumber (2.10 kg) with chitosan application in first sowing date, while it minimum was recorded in Suyo Long (0.31 kg) and Poinsett (0.29) in third sowing date with chitosan application. However, in third sowing date Suyo Long and Poinsett could not survive at fruiting stage without chitosan application.

Key Words: cucumber, chitosan, genotypes, heat tolerance, yield.
ARSenic Contamination of Paddy Growing Areas: Implication on Rice Quality & Human Health

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Millions of people across the globe are at health risk due to arsenic (As) toxicity. As is present in different oxidative states in the environment and enters in the food chain through soil and water. It causes varieties of negative health effects in humans such as cardiovascular disease, hypertension and skin cancer. Rice (Oryza sativa L.) is a staple food for over half of the world’s population and particularly susceptible to accumulate arsenic more efficiently than any other cereal crops. To monitor this situation, the present study was planned to evaluate the As concentration in rice grains from central Punjab villages of Sheikhupura and Hafizabad district. For this purpose, twelve tubewell operated rice fields were selected for sampling. Ground water, Rice grains and straw samples were collected. Rice grains and straw samples were digested separately following the heating block digestion procedure and the total arsenic of the ground water and rice grains samples was analyzed with atomic absorption spectrophotometer. The As concentration was found in majority of water samples and its varied from from 0-11 and 1-24 ppb, at Hafizabad and Sheikhupura district, respectively. Similarly grain analysis also showed that the As concentration in rice grains of Hafizabad and Sheikhupura district varied from 2-52 and 5-38 ppb, with mean value of 21± 0.012 and 17± 0.007 ppb, respectively. This value is lower than the WHO recommended permissible limit in rice (1.0 mg kg⁻¹). This study concluded that rice grains produced in these rice growing areas are safe for human consumption.

Key Words: Arsenic Contamination, Ground Water, Rice Grains, Survey
EVALUATION OF WHEAT GENOTYPES UNDER CADMIUM STRESS AT SEEDLING STAGE

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Industrial revolution is a main issue for whole world now a days because it is affecting to our soil and environment. Some areas of Faisalabad are severely affected by industrial water because cultivated land is irrigated by industrial water. This water is the source of heavy metals and cadmium is one of them. Accumulation of cadmium in grains have health risks for humans. A study was conducted to evaluate the various levels of cadmium (5 mg/L, 10 mg/L, 15 mg/L) on five wheat varieties (Ujala, FSD2008, Galaxy, Anaj & Punjab). Experiment was carried out for 2 weeks in plastic pots filled with sand which was fed with different concentrations of cadmium salt. The phytotoxicity percentage of cadmium on root, shoot, young seedling growth, seedling vigor index and tolerance indices were evaluated. All varieties germinated well on different concentrations of Cd. Analysis of variance showed all the treatments and genotypes showed significant results for shoot length but their interaction was non-significant while treatments, genotypes and their interaction were significant for root length. Phytotoxicity graphs showed variation for root length and shoot length. At 15 mg/L cadmium stress there was maximum effect among other levels of stress 5 mg/L and 10 mg/L, respectively it means the Cd has created the toxicity at different concentration. Root length and shoot length significantly decreased by increasing cadmium concentration. Punjab gave maximum value of tolerance index while Galaxy showed least value of tolerance index.

Keywords: Cadmium, Wheat, Seedling growth, Phytotoxicity, Tolerance index
WATER BORNE DISEASES BY POOR WATER SUPPLY SYSTEM

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Water is indispensable for the human life and all living organisms. Without water life cannot exist on the earth. Every person uses 3 to 5 liters water for drinking purpose daily. The situation of drinking water is very pernicious in Faisalabad due to absence of proper safe water supply and sewerage distribution system. Safe drinking water is the basic right of human. According to the WHO/UNICEF 2017 around 2.1 billion people have no access to the safe drinking water. 0.34 million children under age of five years die every year due the diarrhoeal diseases. About 90% of all natural disasters are related to the water according to the UNISDR. Many people are being affected by water borne diseases in Faisalabad. A study area was selected named Chak. no. 253 R.B, Samundri road Faisalabad. The population of the study area was approximately 7735. The data related to water borne diseases revealed that the people in year 2015 affected by diarrhea under five years were 50, above than five years 35 and by malaria were 13. Similarly, in year 2016 the number of people affected by diseases were 53, 47 and 11, respectively. The people affected by diarrhea under five years were 56, above than five years were 54 and by malaria were 08 in year 2017. The latest figures of last year 2018, people affected by diarrhea were 36, above than five years 34 and by malaria were 08. A survey was conducted to investigate the source of water borne diseases. It was observed that water distribution system was built 30 years ago and presently water supply pipes were damaged. Mixing of sewerage water with drinking water was occurring due to leaky pipes and open sewerage system. It was concluded that old, inefficient and poor water supply system was causing water borne diseases as described above. It was inevitable to design and replace the existing water supply system for that area to avoid all the problems discussed earlier.

Keywords: Water borne diseases, Diarrhea, Malaria, Water supply system
ICSS/IAGC/2019/PP/05

EVALUATION OF GROUND WATER QUALITY IN THE VICINITY OF MADDUANA DRAIN FROM SATYANA ROAD TO JARANWALA ROAD IN DISTRICT FAISALABAD

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Water is an essential and vital component for the existence of life. It is used for various purposes like irrigation and drinking. Due to anthropogenic activities, the water has been polluted and is a major issue now a days. The water quality assessment is therefore important to analyze and preserve the natural source. A study was conducted in an area of Faisalabad district, Satyana road to Jaranwala road along the Madduana drain to evaluate the physical parameters of groundwater of that area which is polluted by waste water. 40 water samples were collected for this purpose along the Madduana drain passing in the area. The physical parameters TDS, pH, DO etc. of water were compared to the standard limits of WHO and NEQS. GIS was used for the mapping of all the parameters which were considered for the better understanding of range of these parameters in the area under consideration. It was observed that the ground water has been polluted and the main reason of ground water pollution was the Madduana drain which is carrying the industrial waste water from the textile sector. The analysis of the samples illustrates that the waste water from the industries should be treated before discharging into Madduana drain so that the ground water could be preserved, ultimately it will help in controlling water borne diseases by enhancing quality of water and life improvement.

Keywords: Drain; GIS; Physical parameters; WHO.
EFFECT OF HEAVY METAL POLLUTION ON CROP PLANTS AND BIOREMEDIATION OF HEAVY METAL AFFECTED SOIL

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Heavy metals pollution is harming our environment very rapidly due to increased human activities that release heavy metals. The heavy metals accumulated in plants may directly or indirectly, find their way into human beings. Depending upon the amount taken up by the plants, they may affect plants health from inhibited growth to death of plants. Therefore, it is essential to study the effects of these heavy metals on living organisms and environment. The main causes of heavy metals pollutions are automobile emissions, mining, fertilizer applications etc. In Pakistan, heavy metals problem is severely affecting our environment and human health but unfortunately, very few teams are focusing on this problem. We are studying the effect of these heavy metals on different crop plants especially wheat and maize. The main problem is heavy traffic therefore we are focusing on the crop plants growing near the national highways and motorways. We have taken our data from plants grown near the road sides (N60, M2 & M3). We have also grown plants in the soil taken from zero and fifty meters from road sides. Furthermore, we have grown plants in soil and under hydroponic conditions supplemented with different concentrations of Cadmium and Arsenic. Our results clearly indicated that plants uptake these heavy metals proportional to the amount present in soil or hydroponic media. The uptake badly affect the plant growth and morpho-physiological parameters. Plant store these heavy metals in leaves and grains that are ultimately consumed by humans either directly or through animals. We have identified maize hybrids and wheat varieties that uptake less Cadmium/Arsenic and can be grown for general cultivation in heavy metal affected areas i.e. the road sides. We have also potential candidates that are good up taker of heavy metals and can be used for bioremediation of heavy metal affected soils. Genetic analysis of plants grown under \textit{in vitro} stress conditions is in progress.
CHANGES IN POLLUTION LEVEL IN RIVER CHENAB FROM CHINIOT TO HEAD TRIM

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Stepping towards industrialization requires water consumption at an alarming rate. Water quality of most of the rivers in Pakistan do not meet the WHO standards. The present study was managed to check the water quality from Chenab Nagar Bridge to Head Trimu. Twelve water samples were collected from different locations. Four samples were collected before the discharge of Faisalabad drain and rest the samples were collected after the discharge of Faisalabad drain. Three parameters including pH, total dissolved solids (TDS) and dissolved oxygen (DO) were studied. It was observed that water quality before the discharge of Faisalabad drain was better than after the discharge. Before discharging, the dissolved oxygen level was better i.e., 5 to 12 ppm but after the discharge it become worse. For pH and dissolves solids the same results were observed. The amount of DO became normal just after 60 to 70 Km, only due to the dilution factor, but still it did not meet the required levels of WHO. These changes in water parameters were only due to the polluted waters entering the river Chenab from different cities such as Faisalabad, Chiniot and Jhang. This rise in pollution level may affect the fauna and flora of the river, moreover it can cause negative impacts on humans as well. There is an immense need to treat wastewater before discharging into the river to reduce the pollution level.

Key words: Chenab river, water pollution, wastewater treatment, water quality
GROUNDWATER MANAGEMENT STRATEGIES FOR DISTRICT CHAKWAL, PUNJAB-PAKISTAN

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Groundwater (GW), which is in aquifers below the surface of the earth, is one of the most important natural resources for Pakistan. GW is the source of approximately 33% of the water that is being used for domestic purposes like water supply schemes and private portable drinking water companies. The other 77% comes from surface water sources. District Chakwal is situated in northern Punjab having coordinates 33°40'38"N and 72°51'21"E. The total area of Chakwal is 6,524 km² and the population is approximately 1.496 million. It lies in the Potohar plateau, which is not considered good agricultural land, because agriculture is totally dependent on the seasonal rain cycles than canal irrigation system. The water table is decreasing with the passage of time. It has been decreased from 80 to 200 ft in the residential areas and 50 to 100 ft in the agricultural areas in the past few years. The major reasons behind this decrease are over-pumping of groundwater for commercial and domestic purposes, lack of natural precipitation, lack of water conservation/storage facilities. All these factors are contributing decrease in ground water table. The problem can be minimized by constructing water storage structures like mini dams and rainwater harvesting facilities for agricultural and domestic use. Over pumping could be stopped by proper monitoring, setting up allowable limits for ground water abstraction and water pricing. The water use can be optimized by adopting modern agricultural techniques and high efficiency irrigation systems. The need of the hour is to take this matter very seriously and groundwater management strategies should be implemented. It is important that groundwater resources be properly considered in national strategic planning.

KEYWORDS: Water table, groundwater management, water conservation structures
SPECTRUM VARIATION OF COTTON WEEDS IN FIELD OF TOBA TEK SINGH AND JHANG DISTRICT OF PUNJAB

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Weeds are one of the major influencing factor of cotton crop yields and production. This appraisal of cotton weeds were carried for determination of distribution and diversity of weeds in field of cotton. For study purpose six sites were selected. To investigate weed flora Quadrate method were applied in selected sites. Ten quadrates about (1m×1m) were selected from each site for data collection. This data was used for determination and calculation of pH, EC and various ionic contents such as Sodium (Na⁺), Calcium (Ca²⁺) and Potassium (K⁺) from soil sample, collected from all sites. The spices of families Amaranthaceae, poaceae, Cucurbitaceae and Fabaceae were more abundant weed species of cotton field of Zaki Chowk, Fakhra Sultan and Chund pur. By using these effective measurements, we can control weeds production in cotton field of sites.

Keywords: Cotton weeds, Quadrate method, Diversity of weeds, EC, pH
EXPLORING THE HEALTH RISK OF ARSENIC IN GROUNDWATER ALONG RIVER RAVI FLOODPLAIN IN PUNJAB, PAKISTAN

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Arsenic (As) contamination has been reported in more than 115 countries, which shows serious health risks to humans and the environment. Arsenic has been categorized as Class I human carcinogen. The World Health Organization (WHO) laid down the permissible limit of As at 10 µg/L. The objectives of this study were to explore the As contamination potential in groundwater and its estimated health risk from unexplored River Ravi tributary. Groundwater samples were collected from different depths of wells and pumps along the River Ravi flood plain of district Sahiwal. Over 250 samples were collected from different villages to assess the As in groundwater. Groundwater samples were analyzed for physico-chemical parameters including color, odor, temperature, redox potential, electrical conductivity (EC), pH, CO₂⁻ HCO₃⁻, Cl⁻, total soluble salt (TSS), sodium adsorption ratio (SAR), Ca²⁺, Mg²⁺, and Na⁺. Total As concentration in groundwater was analyzed using a hydride generation atomic absorption spectrometer (HG-AAS). Assessment model for human health risk was used as given by United States Environmental Protection Agency (US EPA). The range of As concentration in groundwater were 3-134 µg/L (mean value of As concentrations was 23 µg/L). The mean value of EC, pH, CO₂⁻ HCO₃⁻ were 1.427 ds m⁻¹, 7.18, 0 mg/L and 476.67 mg/L while, S.D value were range from 13-26 µg/L respectively. More than 45% of groundwater samples showed higher concentration of As value than WHO safe limit of 10 µg/L. The results show that utilization of As-contaminated groundwater showed serious health threat to the human, and hence needs to adapt mitigation and legislation measures.

Keywords: Arsenic · Contamination · Groundwater · Health Risk · Sahiwal
SOIL-MICROBES-PLANT INTERACTION: A NEW DIMENSION IN SUSTAINABLE AGRICULTURE AND ENVIRONMENTAL MANAGEMENT

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Rapidly increasing human population is expected to make food security a big issue in future. Agriculture sector is facing many drastic issues including land degradation, lesser productivity and food insecurity. Sustainable environment goals can be achieved by sustainable agriculture techniques which are resource conserving, socially supportive, commercially competitive and environmentally sound. Excessive use of chemicals in agriculture, urbanization and industrialization are the key causes in polluting soils and posing threat to ecosystem. Coordinated interactions between plants and microbes have supreme importance for improving plant growth and ensuring sustainable environment. Soil microbial populations and their positive interactions with plants drive stability and productivity of Agro-ecosystem. Interactions of soil microbes with plants include atmospheric nitrogen fixation, organic matter decomposition, suppress plant diseases, enhance nutrient cycling and improve plant growth. Beneficial soil microbes were identified as suitable candidates that may help in sustainable management of environment. Bioremediation is the most effective tool to manage the polluted environment and recover contaminated soils by using microbes. Biofertilizer and biopesticide containing efficient microorganisms improve plant growth in many ways compared to synthetic fertilizers and pesticides and thus help in sustainability of environment and crop productivity. Their proper use in agro ecosystems is changing the scenario of present-day agriculture. In the future, utilization of such microbes in the clean-up of pollutants, waste eradication and combating climate change can provide substantial aid in on-going-greener campaign towards environmental sustainability

Key Words: plant-microbe interaction, biocontrol, sustainability, agriculture, safe environment
STATUS OF AIR POLLUTION DUE TO PM 2.5 IN FAISALABAD, PAKISTAN

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According to Greenpeace report, Faisalabad is the 3rd dirtiest city among the 3000 cities of the world. The report considered the particulate matter PM2.5 as their basic pollutant and monitored through mobile and stationary units in different cities of the world. Punjab Environment protection department is also monitoring the concentration of the pollutants in air through its mobile unit. Data revealed that concentration of PM 2.5 is very high it sometimes goes to 92.355 ug/m³ in a day. As per WHO ambient air standards the concentration of PM 2.5 should not exceed 10 ug/m³ annual or 25 ug/m³ in 24 hours in fact it is lowest level at which total cardiopulmonary and lung cancer mortality have been shown to increase due to long-term exposure. Average data of January 2019 showed that air is highly polluted with PM 2.5 which is damaging for all living organisms. It can cause asthma and heart diseases which leads to death of a person in long run. If we follow the footprints and try to identify the sources, it shows as no of factors; its due to emissions from the car, bus and off-road vehicles e.g. construction equipment, also burning of wood and grass. Industrialization adds fuel to the flame, before independence there was only five industrial units in Faisalabad city. Now, there are 512 largest industrial units along with 60,000 power looms factories are working according to Punjab government official website. It is time to take immediate actions to overcome the current alarming situation of a city. It can be improved by using good quality oil which could be free from manganese and lead. Raw material might be change in industries and implementing the current environmental laws in its original form. That actions could take environment back to feet.

Keywords: PM 2.5, air pollution, industrialization
EVALUATING THE PERFORMANCE OF TECHNOLOGY RICH WHEAT SEEDS IN SALINE AREAS

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Wheat is a staple food in many of the developing and developed nations across the globe. Three quarters of the world’s population depends on this staple food, hence the availability of wheat serves for food security of any country. Salinity is a major abiotic stress in arid and semi-arid environments that severely affecting wheat productivity. To overcome the problem of salinity, a field study was conducted to evaluate the performance of wheat under salinity areas using different technologies. The problem can be mitigated by treating the wheat seeds with certain physical and biological agents which are responsible for early imbibition and emergence of healthy seedlings from the soil suffering from large amount of soluble salts. The growth promoting substances as coating agents were Talcum, Titanium dioxide and Biochar. Coated seeds were compared with non-coated wheat seeds which were taken as control. The objectives of early and improved germination and seedlings with high vigour was achieved with biochar coating of wheat seeds due to increased water holding capacity of porous material and avoidance of entry of soluble salts in seeds which can hinder imbibition and ultimate decreased emergence. Though all growth promoting substances were responsible for increased stand establishment, but satisfactory results were obtained with biochar coating. Seeds coated with biochar produced 29% more emerged seedlings with high vigour as compared to non-coated wheat seeds. Our finding proved that enhanced emergence index and healthy seedlings can be obtained under salinity areas by using seed enhancement techniques. However, a detailed and in-depth research is still required to overcome other soil related problems.

Key words: Coating; biochar; stand establishment; wheat; vigour
WILD FLOWERS OF THE CHOLISTAN DESERT, PAKISTAN

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Many plants are being used for the treatment of different diseases across the world and also have other economic uses. Morphological studies are very valuable and assist in the identification and differentiation of different plants. As there is always problem in the taxonomic identification, and differentiation of different plants species. So morphological studies were carried out as an aid to the identification of economically important plants planted in Cholistan desert, Pakistan. Different morphological parameters such as plant height, pubescence, texture of nodes and internodes, texture of lamina and leaf sheath, length and width of lamina and reproductive characters such as length and shape of flowers and inflorescence of each species were considered in the present investigations. The data was subjected to multivariate (cluster) analysis to assess inter- and intra-specific relationship between plant species of Cholistan desert, Pakistan. The studies showed that different morphological characters such as plant height, pubescence, texture of nodes and internodes, texture of lamina and leaf sheath, length and width of lamina were valuable in the identification and differentiation of different plant species. Different morphological features can be used as an identification tool.

Keywords: Cholistan, flowers
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ARSENIC TOXICITY AND RELATED HEALTH PROBLEMS – WAYS TO RESOLVE IT

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Arsenic poisoning to human population is not limited to any specific part of the world but more number of individuals are limited to premises of Pakistan. Approximately 240 million people of south-east Asia are consuming arsenic at concentrations higher than the non toxic levels of 50 μg/L. Peoples of less than twenty years are mostly the victims of this disease. Chronic exposure, even in sub lethal doses, is creating many health problems in these countries like tumors, cardiovascular disease, polygenic disease, and mental health. This field requires refined research that focuses on development of animal models that will elucidate the toxic effects and comparing it to oncogenic substances. Food safety authority should also have to establish strict punishments to the firms who do not consider the factor of monitoring of lethal doses of arsenic in their products. There is also a need of thorough study of patho-physiology of arsenicosis so that we can develop effective remedies for the persons who are infected with this problem. Cost effective water treatment methods and food safety protocols should be developed to nip the evil in the bud. These considerations will be helpful in safeguarding the public health from arsenic-induced problems.

Keywords: Arsenic, Ground water, Environmental health, Exposure assessment, Public Health.
In the world of increasing climate change, it’s our obligation to trace its effects on various aspects of human activity. Agriculture sector is an integral part of national food security programs and unfortunately it is one of those sectors most sensitive to climate change. Hence food security and welfare is severely compromised due to climate change. Various methodologies including statistical models, integrated assessment models and process models etc. have been employed to evaluate the effects of global climate change on agriculture. These methods give variable yet useful information in this regard. These approaches do confirm the impact of climate change on the agriculture. Environmental sustainability and adaptive strategies may affect the ability to tackle these challenges. Various crop models have been employed to access the effects of extreme environmental events on the crop production. Besides these experimental models, various projects funded by national as well international agencies are also focusing to evaluate the influence of climate change and methods to tackle it. Various recommendations are also being forwarded. The development of international attitude is necessary to handle this menace. We need to develop infra and inter sectorial assessment models which aim to develop appropriate methods to sustain system’s sustainability under the effects of climate change. This is need of time, if we want human race to survive this millennium.

**Keywords:** Climate Change, Agriculture, Sustainability
ADDITIVE EFFECTS OF ORGANIC AMENDMENTS ON ARSENIC MOBILITY AND PLANT UPTAKE: A REVIEW

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The arsenic (As) contamination is a global environmental issue due to its deteriorating effects on ecosystem. Though arsenic exists in ionic form in soil but arsenate (As (V)) is the most predominant form. Many methods are being used to remediate this kind of soil contamination but most of them are costly and produce waste products that require careful disposal. Currently, plant-based technology called phytoremediation with organic amendments is an affordable, eco-friendly approach used to extract or remove metal pollutants from contaminated soil and water. This review aims to compile some information about arsenic (As) sources, effects and their treatments by using organic amendments. It also reviews deeply about phytoremediation/phytostabilization of As and other heavy metal contaminates by using perennial woody vegetation. In agriculture, organic amendments are frequently used to improve the soil properties. Recently, organic waste including animal and poultry manure is being used to remediate of contaminated sites is one of the major sources of organic amendments. Additionally, it describes the effect of different types of organic amendments along with different woody vegetation to reduce As contamination from As contaminated soils. Some recommended nitrogen fixing plants which are commonly used in phytoremediation and their capability to reduce the arsenic contamination are also reported.

Key Words: Arsenic, phytoremediation, organic amendments and nitrogen fixing trees
IRON BASED NANOPARTICLES AS ADSORBENTS FOR ARSENIC REMOVAL FROM DRINKING WATER

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Arsenic (As) is a global health and environmental issue as it is a toxic metalloid. Contamination of drinking water with As is reported globally and more than 115 countries are at As toxicity stake including Pakistan, China, Bangladesh. Arsenic is causing different health disorders including skin cancer, nervous disorders, cardiovascular diseases, and in few cases, diabetes has also been reported. Several different technologies such as oxidation, coagulation, ion exchange, membrane techniques and sorption techniques have been recommended for removal of As from drinking water. Among them, the most promising and efficient removal technique is adsorption technique by using nano-adsorbents. Nano-adsorbents are considered worthwhile on account of their unique physico-chemical properties, high efficiency, large surface area and strong chelating capabilities. Recent studies disclosed that iron-based materials like iron based nano-adsorbents, iron-oxyhydroxide doped bio-composite, and zero-valent iron have been used for removal of As from water. Iron based nanoparticles are non-toxic, environmentally friendly and easily available in huge amount; propound favorable results for As removal from water. Iron based adsorbents have better competence because of their high surface area and reactivity. Different recommendations are made which are based on current nanotechnology practices for water treatment. Overall, iron-based adsorbents put forward significant potential for developing efficient adsorbents for As removal from water.

\textbf{Key words:} Arsenic, Drinking water, Iron based nano-adsorbents, Water purification
INFLUENCE OF SALINITY ON GROWTH AND YIELD ATTRIBUTES OF DIFFERENT CHICKPEA GENOTYPES

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Production and productivity of chickpea landraces in semi-arid areas can be decreased by the influence of soil salinity which is an abiotic factor. From pulse crops, chickpea is the most important legume crop after dry beans. Chickpea is highly salt sensitive and is grown under a wide range of agro-ecological zones. To overcome the salinity stress, a highly attractive approach is to increase the salt tolerance in the plant. The aim of the study is to screen out the chickpea landraces genotype which can be most tolerant in soil saline problems. For this purpose, three chickpea landraces and four levels of salt (NaCl) concentration were experimented. The significant difference was observed in germination percentage, germination rate, radical length and plumule length parameters under saline conditions as indicated by the results. AZRI, Bhakkar 2006, GRS and karak 2003 showed high germination percentage, radical length and plumule length respectively. Most adversely affected parts were the root and the shoot growth, therefore root to shoot ratio was also influenced. Plant productivity was ultimately affected by the negative effect of salinity on the plant growth. The treatments, genotypes, and their interaction was found to be highly significant at (p<0.05) with regards to all parameters indicated by ANOVA. During germination stage, the chickpea landraces AZRI, Bhakkar, 2006, GRS and karak 2003 were salt tolerant. However chickpea landraces BARI, Chakwal 2000 were salt sensitive during germination stage. The rest chickpea landraces were tolerating the salts intermediately. The current study showed that the selection criteria for tolerance in salt affected soils are the morphological traits.

Key words: Chickpea landrace, Salinity, Tolerance, Yield.
RESPONSE OF SOYBEAN GROWTH AND YIELD TO THE RHIZOBIUM ALONG WITH ORGANIC MATTER AND MINERALS

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Cheaper and best source of proteins are pulses to feed in the rapidly growing world, especially in developing countries. Soybean contains about 36% proteins, so it would be the better source to meet their requirements. For the production of sufficient and healthy food, it is necessary to fulfill the requirements of plant nutrition of the soybean for the expanding population. Rhizobium species also increase the yield and productivity of crop plants especially the green legumes. For this purpose, press mud was used as organic matter which is a potential source of many major nutrients and minerals required for sustainable plant growth. Mineral was used as an ideal trap for positive ions like ammonium, potassium and calcium etc. Pakistani soils are alkaline in nature and have deficiency of major plant nutrients, so proper nutrient management is required for sustainable agricultural productivity. A pot experiment was conducted in completely randomized design (CRD) to evaluate either Rhizobium along with press mud and mineral material which could increase the yield of soybean. There were twelve treatments along with three replicate in which the given amendments were applied in different combinations. Suitable agronomic and plant protection measures were carried out. Pre and post research analysis were carried out using most compatible methods. All the collected data was statistically analyzed for Analysis of Variance (ANOVA) using suitable statistical software. Plant height, dry mass and chlorophyll content were recorded in the treatment T₁₂ (Rhizobium+ O.M and mineral matter) which was better than other treatments and highly significant. It was concluded that combined effect of rhizobium, organic matter and mineral of aluminum were better and environmental friendly.

Keyword: Mineral; Organic matter; Soybean yield and Plan Nutrition.
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INORGANIC ARSENIC: ETIOLOGY FOR TYPE 2 DIABETES AND A DETOXIFICATION INDICATOR

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Inorganic arsenic, an environmental oncogenic and diabetogen, is ranked as first in the US Priority List of Hazardous Substances, affecting over 300 million peoples of 70 countries. It naturally occurs as sulfide in over 200 mineral species into air, water, soil, groundwater, fossil fuels and volcano being the most significant contributor. Methylation of it by arsenic methyltransferase into methylarsenates, mainly by the liver and secreted in urine, led to consider this in detoxification. Diabetes at even low-to-moderate exposure levels by dysfunctionality of pancreatic islets, reducing insulin mRNA expression in pancreatic β-cells and suppressing Ca^{2+} influx, inhibiting insulin vesicle packaging and impairing glucose-stimulated insulin secretion can be detected through a list of miRNAs as biomarkers. It also induces a significant Nrf2-mediated antioxidant response, which suppresses endogenous reactive oxygen species that are thought to be involved in insulin secretion, inhibits differentiation of fat cells by decreasing expression of PPARγ resulting in reduced insulin sensitivity and signalling, which play a major role in glucose utilization and energy homeostasis, enhances gluconeogenesis, likely promote hepatic glucose production, disrupts estrogen receptor mediated gene regulation. Arsenic hypermethylates the promoters of 183 cardiometabolic genes, non coding RNAs and DNA of peripheral blood leukocyte, elevates folate. Proofs of microRNAs are still not sufficient to declare arsenic to be a diabetogen and requires furthers investigation with special emphasis at molecular level.

**Keywords**: Inorganic Arsenic, Type 2 Diabetes, Detoxification Indicator, Antioxidant.
INORGANIC ARSENIC: TOXIC & DETOXIFICATION INDICATOR, ITS BIOMARKERS AND MITIGATION STRATEGIES

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Approximately 240 million people of south-east Asia are consuming arsenic at concentrations higher than the threshold levels of 50 μg/L. Peoples of less than twenty years are mostly the victims of this toxicity. Chronic exposure, even in sub lethal doses, is creating many health problems in these countries like tumors, cardiovascular disease, polygenic disease and mental health. Methylated metabolites of inorganic arsenic, especially the trivalent forms, are more toxic than the inorganic arsenicals. MicroRNAs reside in protein and non-protein coding regions with their own independent transcription units, do the fine-tuning of gene networks. Transcription leads to a primary miRNA transcript that form hairpin like secondary structures are recognized and excised in the nucleus by DGCR8 and DROSHA, resulting sequence, known as a precursor miRNA, is exported from the nucleus into the cytoplasm by Exportin 5-Ran-GTP. Dicer cleaves the end of the pre-miRNA to produce a double stranded RNA duplex and loads onto the RNA Induced Silencing Complex, at which point the miRNA is ready to guide and tether Argonaute to target RNA sequences, conferring gene silencing by translational repression and/or mRNA degradation. Diabetes at even low-to-moderate exposure levels by dysfunctionality of pancreatic islets, reducing insulin mRNA expression in pancreatic β-cells and suppressing Ca\(^{2+}\) influx, inhibiting insulin vesicle packaging and impairing glucose-stimulated insulin secretion can be detected through a list of miRNAs as biomarkers. It also induces a significant Nrf2-mediated antioxidant response, which suppresses endogenous reactive oxygen species that are thought to be involved in insulin secretion, inhibits differentiation of fat cells by decreasing expression of PPARγ resulting in reduced insulin sensitivity and signalling, which play a major role in glucose utilization and energy homeostasis, enhances gluconeogenesis, likely promote hepatic glucose production, disrupts estrogen receptor mediated gene regulation. Arsenic hypermethylates the promoters of 183 cardiometabolic genes, non coding RNAs and DNA of peripheral blood leukocyte, elevates folate. Proofs of microRNAs are still not sufficient to declare arsenic to be a diabetogen and requires further investigation with special emphasis at molecular level. Cost effective water treatment methods and food safety protocols should be developed to nip the evil in the bud. These considerations will be helpful in safeguarding the public health from arsenic-induced problems.

Keywords: Arsenic, Detoxification Indicator, Biomarkers, Mitigation.
UNVEILING THE IMPACTS OF DIFFERENT AMENDMENTS ON TWO CONTRASTING RICE GENOTYPES UNDER ARSENIC STRESS IN PADDY SOIL-RICE SYSTEM

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Arsenic (As) contamination of groundwater is an emerging environmental, agricultural and human health issue worldwide due to its toxic nature. Under paddy soil conditions, As becomes highly mobile and bioavailable to rice (Oryza sativa L.) plants, which is consumed as a staple food by more than 3 billion people around the world including Pakistan. The objectives of the present study were to: (1) explore the accumulation of As in different parts of rice plants of two contrasting rice genotypes (Kainat and KSK-385), and (2) evaluate the effect of As on morphological and physiological parameters of rice plants. Six types of organic (farm yard manure (FYM), cow dung (CD), biogas slurry (BGS), mixed biomaterials waste (MBW)) and inorganic (gypsum, lignite) amendments were applied to determine their impact on soil As availability and uptake by two different rice genotypes under paddy soil conditions. Arsenic-contaminated irrigation water was applied to rice plants after 15 days of transplantation, and each irrigation was applied at three equal intervals – each irrigation contained 15 mg As/L (400 mL per 2 kg soil). We found that the percentage increase in number of tillers ranged from 28–51% and tiller length spanned 28–50% with the maximum values obtained for FYM over their respective control for KSK-385 genotype. In case of Kainat genotype, number of tillers and tiller length ranged from 41–50% and 18–33%, respectively, with the maximum values attained for CD treatment compared to control. Soil pore water samples were taken at four different growth stages from rice plants rhizosphere, EC, pH and redox were monitored to analyze the changes in these parameters that were induced in the soil by different amendments. This study showed that organic amendments, particularly FYM and CD, could possibly enhance the growth and yield of the two rice genotypes under irrigation with As contaminated water.

Key words: Arsenic, Rice, Genotypes, organic and inorganic amendments.
UNVEILING THE POTENTIAL OF INDIGENOUS WETLAND PLANT SPECIES FOR THE TREATMENT OF CHROMIUM-CONTAMINATED WASTEWATER

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There has been much interest recently in the use of constructed wetlands (CWs) for the removal of chromium (Cr) from wastewaters. Wetland plants play an important role in the Cr removal process. It is not known however; which wetland plant species has the greatest efficiency in Cr removal from contaminated water. Such knowledge is essential to maximize the efficiency of Cr removal by wetlands. The objective of this study was to assess the potential of six different wetland plant species (Phragmites australis, Typha angustifolia, Canna indicia, Laptochloa fusca, Brachiaria mutica and Cyprus roduntus) in vertical flow CWs (VF-CWs) to remove Cr from contaminated water. Six indigenous wetland plant species were planted in the CWs to explore their efficiency to grow and detoxify Cr from Cr-contaminated water. Chromium (as potassium dichromate) solution was applied at two levels i.e. 15 and 30 mg/L. All wetland plant species showed great tolerance towards Cr contamination and grew well under the stress of 15 mg/L except Typha angustifolia. At higher Cr concentration, Laptochloa fusca and Cyprus rodents showed better growth. It can be concluded that the constructed wetland species Laptochloa fusca and Cyprus rodents may have great efficiency to remediate Cr from the contaminated water.

Keywords: Chromium, wetland plants, Cr-contaminated water
HEALTH RISK ASSESSMENT OF ARSENIC IN DRINKING WATER OF DERA GHAZI KHAN DISTRICT OF PUNJAB, PAKISTAN

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Geographic arsenic (As) contamination in groundwater has been recognized as a major health and environment risk globally, threating millions of people with As contamination via intake of drinking water. World health organization (WHO) set the permissible limit of As in groundwater at 10 micro g/L. We explored the As contamination potential, heath risk and other water quality parameters in groundwater from previously unexplored rural and urban areas of Dera Ghazi Khan in Punjab, Pakistan. Groundwater samples (n = 400) were collected and analyzed for the chemical properties and total As. The mean values of electrical conductivity (EC), pH, redox potential (Eh), dissolved oxygen were 1.18 dS m⁻¹, 7.73, -41 mV and 4.89 mg L⁻¹ respectively. This study highlights that high As content in groundwater of study area is an emerging issue, as well as in context of some other water quality parameters, the groundwater is not fit for human consumption. Hence immediate remediation and mitigation measures should be adopted to overcome the As toxicity in these areas of Pakistan.

Key words: Arsenic, groundwater, contamination
REMEDICATION OF ARSENIC-CONTAMINATED WATER USING BIOCHAR-BASED SORBENTS

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Geogenic arsenic (As) contamination is an emerging issue worldwide, especially in South and Southeast Asian countries including Pakistan. Over 200 million people are at stake of As toxicity and about 110 million people reside in Southeast Asia. The inorganic forms of As in groundwater present as arsenite (As(III)) and arsenate (As(V)). World Health Organization (WHO) has set permissible limit of As at 10 μg L⁻¹ for groundwater, but for Pakistan and some other countries its permissible limit is 50 μg L⁻¹. Arsenic can be removed from water by many approaches including adsorption, chemical precipitation, coagulation, electrochemical technology, membrane process, and ultrafiltration. These methods are effective for removing As, but produce hazardous sludge, require intensive labour and high cost. The sorption of As using biochar is an effective method due to its high adsorption capacity. The efficiency of biochar to remove As from drinking water can vary from 80–90%. More research is needed on focusing the biochar capacity and its adsorption rate to remediate As in water. Also, immediate legislative and mitigation measures are needed to overcome As toxicity and its removal from groundwater.

Key words: Arsenic, Groundwater, Biochar, Water purification
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REMEDIATION OF CHROMIUM-CONTAMINATED TANNERY WASTEWATER BY USING CONSTRUCTED WETLAND TECHNOLOGY

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Industrial effluents are a source of contamination for aquatic environment. Wastewater is complex in composition also causing many adverse effect on environment and human health due to presence of heavy metal mainly chromium. Major forms of chromium are chromite Cr (III) and chromate Cr (VI) are mainly found in leather tanneries wastewater. Chromate is the most toxic form of Cr with no metabolic function in living organism. High level of Cr concentration in industrial wastewater especially in leather tanneries which uses excessive amount of Cr salts in the processing. Recent studies show that among physio-chemical parameter electrical conductivity, pH, cation and anion were found to be higher than the permissible limit of NEQS in the wastewater samples collected from tanneries of different cities of Punjab, Pakistan. Chromium showed detrimental effects on skin including dermatitis and allergic reaction such as severe redness of skin. Lining of upper respiratory tract may effected by Cr (VI). Symptoms of respiratory disorder include coughing and wheezing, shortness of breath and nasal itch. For remediation of Cr from the wastewater different approaches were used but each of them has its own limitations. Constructed wetland is an emerging engineering approach to remediate Cr from tanneries. Inside constructed wetland removal and reduction of chromium by plant uptake and by sorption onto porous media and sediments. Constructed wetland treatment of wastewater has proved to be an efficient strategy in treating contaminated wastewater. This approach has the efficiency of removing 90-95% from wastewater. The constructed wetland technology can be an efficient and environmental friendly way to remove Cr from wastewater. Also, further research has to be done on understanding the mechanisms and factors that affect the biogeochemistry of Cr under CWs technology.

Key words: Chromium, Tannery wastewater, Constructed wetlands
FOREST COVER CHANGE DETECTION USING GEOGRAPHICAL INFORMATION SYSTEM AND REMOTE SENSING TECHNIQUES

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Forest land cover change detection analysis is not new, the emergence of new imaging sensors and geospatial technologies has created a need for image processing techniques that can integrate observation from a variety of different sensors and datasets to map, detect and monitor forest resources. In addition to timber, forest provide such resources as grazing land for animals, wildlife habbitat, water resources and recreation areas and these are threatened constantly by both human impacts like forest fires, air pollution, clearing for agriculture uses, and illegal cutting, farming activities and natural activities like land sliding, soil erosion, and increase in the environmental temperature led to decrease in forest. This study was to analyze of forest change detection in tehsil dir, pakistan from 2000 to 2017. For analyzing these variations in forest two temporal based images of land sat satellite was used. Both the images was classified for categorization of land use and land cover in five different classes i.e. forest, settlements, barren land, agriculture and water bodies. The result of this research shows that the forest area in the year 2000 was 1800020 acres and the influence was 37.68%. In 2017, the forest area was reduced to 117,951 acres (24.69%) of the total area. In tehsil Dir forest was reduced 12.99% in last 17 Years. Changes in forest structure, composition and landscape pattern indicate severe degradations going on with the forest in tehsil Dir, Pakistan. The state government has therefore continued to impose ban on indiscriminate falling of trees in the state.

Keywords: Forest cover changes, Land Use/Land Cover, GIS, RS.
REMOVAL OF PHENANTHRENE FROM CONTAMINATED WATER USING PLANT BACTERIA SYNERGISM IN CONSTRUCTED WETLANDS

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Water crisis is getting worse day by day. So, polluted water is one of the major environmental problems in the world especially in the developing countries fighting with the crisis of good quality water. Pakistan is at 80th among the 122 countries who are consuming the low-quality drinking water. Anthropogenic activities are the main cause of water pollution in the developing countries. Polycyclic aromatic hydrocarbons (PAHs) are generated in the environment, where biofuel is used and burning process is not completed. PAHs are toxic to all living organisms. It is one of the biggest challenges for the researchers or scientists to treat the water containing PAHs in cost-effective and efficient way. Use of constructed wetlands (CWs), augmented with specific bacteria, is an innovative approach for the remediation of water contaminated with hydrocarbons. The major objective of this study was the remediation of water contaminated with phenanthrene using plant-bacteria synergism in CWs. The residual amount of phenanthrene in water was analyzed by FTIR. The results showed that the CWs efficiently removed the phenanthrene from the water and its maximum (85%) removal was observed by the plant-bacteria synergism in CWs. Similarly, more COD, BOD and TOC was removed from the water by the plant-bacteria synergism in CWs. Inoculated bacteria showed not only persistence but also hydrocarbons degradation potential. This study revealed that the partnership of plant and bacteria in CWs is potent to degrade phenanthrene in more effective and efficient way than the treatment had only plants.

Key words: constructed wetlands; plant-bacteria synergism; Phenanthrene; hydrocarbon contaminated water
MANAGING IRRIGATION WATER UNDER CLIMATE CHANGE IN BALOCHISTAN PROVINCE OF PAKISTAN

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Pakistan is among countries being adversely affected by climate change. The already depleting sources of water resources are expected to become even scarcer under climate change. This alarming situation demands for sustainable management of the available water supplies. This study analyses farmers’ perceptions of climate change impact on irrigation waters and the adaptation strategies of farmers to dynamic water supplies subject to climate change. For analytical purpose data were collected from 120 randomly selected farmers from Balochistan. Three independent logit models were employed to assess the impact of farmers’ perceptions of climate change impacts on water availability during the last decade and their attitude towards taking risk of adopting water management strategies at farm level. Result reveals that higher educational attainments significantly encourage adoption of shifting to crops requiring less water as a strategy to manage irrigation water while it discourage the use of structural adjustment at farm to manage scarce water. Higher monthly incomes significantly enhance chances of adopting advance irrigation systems while discourage use of shifting to crops requiring less water. Respondents perceiving higher changes in water availability due to climate change have more chances to shift to crops requiring less water while higher perceptions significantly discourage the use of structural adjustment to manage irrigation water. Risk seeker farmers are more likely to adopt shifting crops requiring less water while less likely to use less water in same cropping pattern by structural amendments at farm. Findings suggest that the government should provide technical assistance to the farmers on water conservation technique and the use of modern irrigation systems.

Key Words: Climate Change, Water Management, Perceptions, Adaptation, Irrigation water
EPIDEMIOLOGICAL STUDY OF WATER BORNE DISEASES OF DISTRICT GUJRAT, PUNJAB, PAKISTAN

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Waterborne diseases are the major public health concern in developing countries like Pakistan. Waterborne diseases are very common because of improper sanitation system and unavailability of safe drinking water in rural areas. About 44% of the community in Pakistan lack the access to safe drinking water. Gujrat district consists of three Tehsils, 119 union councils, and 1,065 villages. Area of district is 3,192 sq.km and population is 2,048,008. Total Housing Units of the district are 305,097 of which only 64,554 (21.15%) have been facilitated with piped water. Due to drinking contaminated water the people of district Gujrat suffer greatly from disease like diarrhea, Typhoid, and Dysentery. In this study, exploratory as well as descriptive methods used to analyze the data and information. This study carried out to evaluate the water quality of the targeted area. Very high water pollution was observed during the study which causes waterborne disease among the villagers. Increasing no. of waterborne disease need some preventive measure like the government of Pakistan should improve water distribution system. Prevention of future outbreaks does not demand perfection, only a commitment to learn from past mistakes and to act on what has been learned.

Keywords: Water, Disease, Epidemiological
HEAVY METALS A GLOBAL THREAT: COMPARISON IN REMEDIATION TECHNOLOGIES FROM WASTE WATER

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Heavy metal pollution is a serious global threat degrading the quality of the soil water environment. Rapid industrialization and disposing-off its waste material into different water bodies like streams, lakes and the irrigation water channels, are the major cause of pollution that directly and indirectly affects human, animal and plant health. Therefore, removal of heavy metals from such systems is of special concern due to their obstinacy and persistence in the environment. To tackle this situation various treatment methods have been thoroughly developed for the removal of heavy metals from wastewater such as membrane filtration, chemical precipitation, flotation, adsorption, coagulation–flocculation, ion-exchange and electrochemical methods. Membrane filtration, and adsorption are the most frequently used and effective methods for the treatment of heavy metal wastewater. Membrane filtration technology can eliminate heavy metal ions with high efficiency but adsorption through low-cost adsorbents and biosorbents was highly recognized as an effective and economic method for removal of heavy metals from wastewater.

Keywords: Heavy metals, Pollution, wastewater treatments, Environments
EXPLORING ARSENIC ACCUMULATION TO RICE UNDER PADDY SOIL CONDITIONS UNDER THE IMPACT OF DIFFERENT ORGANIC AND INORGANIC AMENDMENTS

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Geogenic and anthropogenic contamination of groundwater and soils with arsenic (As) is a global, environmental and public health issue due to its poisonous nature. In soil environments, mobility and bioavailability of As especially in rice fields increased due to reduced soil conditions, which is an emerging issue for human food security and health. This is because rice is staple food of about 3 billion people throughout the world. The present study was conducted to explore the accumulation of As in rice different parts of rice (Oryza sativa L.) plants of the two contrasting rice genotypes (Kainat and KSK-385) and evaluate the effect of As on morphological and biochemical parameters of rice plants. Six types of organic (farm yard manure (FYM), cow dung (CD), biogas slurry (BGS), mixed biomaterials waste (MBW) and inorganic (gypsum, lignite) were applied to determine their impact on As availability and uptake by two different rice genotypes. Arsenic-contaminated irrigation water was applied to rice plants after 15 days of transplantation in three intervals. It was observed that the percentage increase in number of tillers ranged from 28–51% and tiller length spanned 28–50% with the maximum values obtained for FYM over their respective control for KSK-385 genotype. In the case of Kainat genotype, number of tillers and tiller length ranged from 41–50% and 18–33%, respectively, with the maximum values attained for CD treatment compared to control. This study highlights that organic amendments, notably FYM and CD, could possibly have nutritional effect, although contrasting, on the growth of two rice genotypes under As stress, thus providing an essential strategy to mitigate As accumulation in rice under paddy soil conditions. Further analysis of As in rice tissue and in different soil fractions in this study will help identify As bioavailability and transfer in paddy-soil rice system.

Key words: Rice, Genetic, Arsenic, Organic, Inorganic, Amendments, Agronomic.
APPLICATION OF BANANA COMPOST ENHANCES PHYTOREMEDIATION AND ALLEVIATES THE PETROLEUM HYDROCARBONS TOXICITY TO MAIZE

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Petroleum hydrocarbons (PHs) are considered as non-degradable organic pollutants. PHs are ubiquitous and one of the major sources of contamination due to accidental oil spills. PHs and their products contain hazardous compounds which are toxic to all living organisms including plants. Phytoremediation is a common approach used for their removal. To enhance the phytoremediation and to alleviate their phytotoxicity, plants are often assisted with microbes and different organic amendments. In this study, we examined the effect of banana compost addition on phytoremediation and growth of maize (Zea mays L.) in diesel-contaminated soil. For this purpose, a pot experiment was conducted having artificially contaminated soil with diesel (15g/kg dry soil). After 30 days of aging, maize seeds were sown, and banana compost was applied to the soil in the selected pots. Results showed that PHs negatively affected the root and shoot growths of plants by reducing their lengths and fresh and dry biomass. Furthermore, seed germination, fluorescence yield, photosynthetic electron transport rate, chlorophyll content, rate of photosynthesis and stomatal conductance were significantly reduced in PHs-contaminated soil. Interestingly, the application of banana compost considerably improved the PHs removal and growth of maize in PHs-contaminated soil. Our findings may have important implications in improving phytoremediation and plant productivity in PHs contaminated soils through organic amendments.

Key Words: Maize, Compost, Phytoremediation, Diesel, Crop Productivity
MICRO RNAs: BIOMARKERS OF ARSENIC

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Arsenic, a major environmental pollutant, has contaminated drinking water as the main source that exceeds that tolerable threshold of 10 μg/l and results in degenerative, inflammatory and neoplastic changes of skin, respiratory system, blood, lymphatic, nervous and reproductive system without having any treatment at chronic stages. Inorganic arsenic is metabolized by reduction and oxidative methylation. Methylated metabolites, especially the trivalent forms, are more toxic than the inorganic arsenicals. MicroRNAs reside in protein and non-protein coding regions with their own independent transcription units, do the fine-tuning of gene networks. Transcription leads to a primary mRNA transcript that form hairpin like secondary structures are recognized and excised in the nucleus by DGCR8 and DROSHA, resulting sequence, known as a precursor miRNA, is exported from the nucleus into the cytoplasm by Exportin 5-Ran-GTP. Dicer cleaves the end of the pre-mRNA to produce a double stranded RNA duplex and loads onto the RNA Induced Silencing Complex, at which point the mRNA is ready to guide and tether Argonaute to target RNA sequences, confering gene silencing by translational repression and/or mRNA degradation. mRNAs can also be secreted into circulation and serve as stable plasma biomarkers of disease. There is a need to apply sequencing technology to study the most responsive mRNA that may be the therapeutic biomarker against this disease.

Keywords: Arsenic, microRNAs, Biomarkers, Sequencing
ROLE OF ORGANIC AMENDMENTS IN PHYTO-AVAILABILITY OF CADMIUM TO RICE

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Soil serves as a natural potential source of nutrients for plant growth and development and it is also the largest sink for contaminant. Contamination of heavy metals in soil is increasing with each passing day from different industrial releases. Pollution of cadmium is very hazardous to humans, plants and animals as it gets entry through the food chain. Its phyto availability can be reduced by using organic amendments which make different unwavering organic complexes. This experiment was conducted to test the effectiveness of organic amendments like farmyard manure, poultry manure and rice husk biochar for alleviating Cd toxicity. The amendments were applied @ 1% (w/w). The results showed a significant decreased of Cd concentration in rice plants and soil as compared to control. Maximum reduction in Cd concentration in the shoot and grains was observed by applying the biochar from rice husk. The maximum increase in yield was also observed in rice husk biochar treated soil. Physiological parameters of plants like fresh and dry weight of straw and roots, Plant height and chlorophyll contents were increased significantly by the rice husk biochar amendment. All the amendments showed positive response as compared to control but there was a significant difference among treatments. Biochar from rice husk may be the very good choice in heavy metal polluted soils especially with Cd.

Key Words: Organic; Amendment; Biochar; Heavy metals; Phytoavailability
DEVELOPMENT OF INDIGENOUS MICROBIAL BIORESOURCES FOR BIOREMEDIATION OF DIESEL CONTAMINATED SITES

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Petroleum hydrocarbons (PHs) belong to the family of organic compounds which are very persistent in nature. Processing of crude oil in industries, manufacturing of different products, and transporting and storage of different petroleum products have resulted in the PHs contamination in most of the countries including Pakistan. Contamination by PHs has greater environmental concern because of their toxicity to all living bodies including human being. Thus, the cleaning of PHs-contaminated environment is crucial. Among existing PHs remediation options, microbially mediated degradation is considered the most economical and environmentally-friendly. This study is aimed to develop indigenous PHs-degrading microbial consortia using soil samples collected from the various PHs-contaminated sites in Pakistan. First aerobic incubation was performed in 200-mL Erlenmeyer flasks containing 90 mL of an autoclaved mineral-salt medium, diesel (10g per liter, as PHs) and 10 g of PHs-contaminated soil (as inoculum). After the first enrichment experiment, three sequential sub-culturing was performed to select enrich PHs-degrading microbes. PHs removal and microbial growths (optical density) were monitored using TPH analyzer and spectrophotometer, respectively. Results showed that the microbes in the developed consortia have potential to grow and degrade PHs under the tested conditions. After these culture optimization experiments, the developed consortia will be used in combination with selective crop plants in the rhizoremediation trials on soil artificially contaminated with PHs.

Key Words: Bioremediation; PHs; Bioresource Development; Rhizoremediation
CURRENT INNOVATIVE ADVANCEMENTS FOR DEBORONATION FROM WATER BODIES

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In the recent years boron (B) pollution has become an escalating global environmental threat contaminating our precious water sources because of its extensive usage in industrial products, agricultural chemicals and intensive mining operations. A long-term excessive intake of B causes a number of human health effects like dysplasia, fetal malformation, infertility and damage of nervous system. Globally about one billion people are facing extremely limited excess of safe irrigation and drinking water and the demand is further predicted to rise by 50% by 2030. Therefore, several technologies and methods have been developed for safe deboronation from both drinking and wastewater. This paper review these techniques, like thermal desalination, adsorption techniques, electrocoagulation, and ion exchange, reverse and forward osmosis, membrane bioreactors, and Hybrid techniques combining ion-exchange with membrane filtration (ultrafiltration or microfiltration). However, most of these have numerous limitations. Very recently some cost effective and no-waste generating methods have been developed for deboronation that can be used effectively to remove B from drinking and wastewater. Some of them are use of eggshell waste as an adsorbent, bipolar membrane electro dialysis (BPED) and defect-free highly selective MPD-TMC with removal efficiency of over 96.3 %, 90% and 90% respectively.

Key Words: Boron pollution, deboronation, health, water
BORON POLLUTION: A POSSIBLE THREAT TO ENVIRONMENT

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Boron (B) is considered essential for normal plant growth and also plays beneficial role in other living bodies including humans. However, at higher levels, it becomes harmful or even lethal to plant and human health. In humans its excess damage kidneys, liver, nervous system and causes permanent infertility. Moreover, B contaminated aquatic ecosystems are also facing severe ecological implications. Over the years, B usage has been increased tremendously at industrial and agricultural level as well as in mining and coal burning practices that lead to a dramatic buildup of B in soil and water environments. For instance, approximately 500 million tons of coal fly ash is yearly discharged all over the world and B is among the primary pollutants in these materials. Additionally, B also generates complexes with other heavy metals where it further aggravates the problem. For that reason, B pollution has turned into a global environmental problem causing substantial lethal impacts. In recent years number of technologies have been developed for its removal, but there is no easy or simple way that is in the same time economical and effective. Therefore, there is a dire need to develop environment friendly and cost-efficient methods for its safe removal.

Key Words: Boron pollution, infertility, environment, water.
Comparative Efficiency for Salt Tolerance Among Different Rice Varieties Under Saline Condition

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Root zone salinity is a major cause of lower crop production in arid and semi-arid regions. Use of salts rich water for irrigation purposes further aggravates the problem for crops like rice that requires huge amount of water. A hydroponic experiment was conducted to check the salt tolerance efficiency of local rice varieties (KSK-434, Chenab Basmati, Bas-385, Bas-515 and Shahen Basmati) with some foreign salt tolerant varieties (Bina Dhan-8, Dhan-47, Gosaba and Dhan-55). All varieties were exposed to 3 different levels of salinity stress i.e. 0, 60, and 100 mM NaCl. At the end of experiment, fresh and dry biomass, root and shoot length, chlorophyll (SPAD value), MSI, RWC and Na\textsuperscript{+}/K\textsuperscript{+} were determined. Growth and dry biomass of plants were reduced significantly after 28 days of stress. Gosaba and Chenab Basmati were the most tolerant varieties against salt stress at 60 mM and 100 mM NaCl stress.

\textbf{Key Words:} salinity, stress, tolerance.rice, IRRI
TEMPORAL RELEASE OF BORON AND PHOSPHORUS IN BIOCHAR AMENDED SOIL BY USING BIOCHAR AND BORON COATED DAP


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Agriculture is the backbone of Pakistani economy but as the time passes Pakistani soils get shortage of macro as well as micronutrients. Boron (B) represents one of the micronutrients necessary for proper plant growth and its concentration is affected in the absence or high level. In macronutrients, phosphorus (P) plays an important role in the normal growth and maturity of the plant. P plays a role in photosynthesis, respiration, energy storage and transfer, cell enlargement and cell division. Application of P and B require some attention as they easily leached down from the soil and become unavailable for plant. Leaching of P from the soil cause eutrophication in underground water in which different algal and fungal growth occur due to excess of P. P also get fixed by some minerals in the soil and get absorbed by the soil. In the high rain fall areas and well irrigated lands, the broadcasting of B also results in the leaching of B from the soil. To overcome this leaching problem and B uptake and to check the possible interaction of B with P, formulation of two types of fertilizers was done; 1) simple blending of B and DAP. 2) coating of DAP with B (0.5%) and different level of biochar (2, 4 and 6%). An incubation study was conducted in the lab to check the temporal release of B and P from these fertilizers. Samples were analysed to investigate the release of B and P with time after 10 days interval. The result showed that the overall effect of coated fertilizers was good as compared to blended fertilizers as release of B and P was slowed down compared to uncoated fertilizers.

Key words: Boron; DAP; Biochar and Coating.
EFFECT OF MICROBIAL CONSORTIUM AND COMPOST ON PHYTOREMEDIATION OF PETROLEUM HYDROCARBONS AND GROWTH OF MASH BEAN

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The contamination of petroleum hydrocarbons (PHCs) is a major soil ecological problem. PHCs are harmful to all living organisms including plants, animals and humans. Thus, removal of these contaminants from the polluted environment is crucially needed cleaning up of these pollutants from environment is a major environmental challenge. Many physical, chemical and biological remediation had investigated to remove petroleum contamination. Use of plants in combination with microbes for phytoremediation of PHCs believed to be an environmentally friendly and cost-effective option. This research was aimed to assess the effects of indigenous microbial consortium and compost addition on phytoremediation of PHCs on growth of mash bean in PHCs contaminated soil. For this purpose, artificially diesel contamination in soil @ 6 g/kg was applied for 30 days to spike the soil. After spiking, nine different treatments were applied by following completely randomized design (CRD). Recommended doses of nutrients (NPK) were applied at the time of sowing. After 90 days of sowing, crop plants were harvested and different physiochemical parameters were recorded by appropriate instruments adopting standard procedures. Results showed that the seed germination was higher in the treatment with both compost and microbes than in the treatment with compost or microbes only. Similar trends and effects of compost and microbes were observed in shoot length, root lengths, fresh and dry biomasses as well as other parameters. Our findings suggested that the combined use of compost and microbes could be more helpful in improving phytoremediation of TPHs and growth of mash bean in TPHs contaminated soil.

Key Words: Contaminants; petroleum hydrocarbons; microbes; phytoremediation
PRODUCING GENETICALLY VARIABLE TOBACCO LINES THROUGH MOLECULAR APPROACHES

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A proficient and reproducible in vitro regeneration system was standardized for wild tobacco named as Nicotiana plumbaginifolia. Initially, some already reported tissue culture protocols were examined. Based upon these results, in vitro regeneration was attempted by culturing leaf segments on MS medium augmented with a variety of plant growth regulator’s combinations. Various combinations of kinetin and IAA was tested. Individual shoots placed on MS medium with/without IBA for rooting. In present study, 1mg/L kinetin and 0.25mg/L IAA combination proved best result for regeneration. Individual cuttings were successfully rooted on MS medium without IBA. Then, it was transformed using biolistic transformation method with gus gene. The bombarded tissues showed best activity on histochemical assay even after a week.

Key Words: Tobacco, Histochemical assay, Kinetin
ECONOMICALLY FEASIBLE AND ENVIRONMENTALLY SAFE SOLID WASTE MANAGEMENT

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Faisalabad is the third largest city of Pakistan and generates solid waste that remains a challenge to manage for government. The organic matter (OM) from such a large-scale production can be used to produce compost for commercial purpose. The objectives of this study were to design an In-Vessel composter and to raise local awareness about the value and opportunities of compost production as well as its commercialization. Based on available data of eight major cities of Pakistan, a model has been developed (OM = 0.1988X1.0577; where X stands for organic waste; R² = 0.997) for the calculation of amount of OM available for producing compost. A survey questionnaire was developed for the community awareness and for collecting organic waste information from various small businesses in the city. The developed model was used to calculate commercial value of their waste and thereby convincing the participating businesses for using the newly developed composter profitable management of their solid waste. A 5-year business plan of the composter uses “Income (PKR) = 0.1988X1.0577×0.07×150” model and reflects economic viability and environmental acceptability of the designed In-Vessel composter for small scale businesses in the developing countries.

Key Words: Compost, Engineering Design, Faisalabad, Organic Waste, Small Business
REMOVAL OF CHROMIUM FROM TANNERY INDUSTRY EFFLUENT USING RICE HUSK

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Industrialization has been increasing gradually in developing countries like Pakistan. Industries discharge organic and inorganic wastes including heavy metals into the environment. Chromium (Cr) is one of the carcinogenic and toxic heavy metal. It is non-biodegradable and can produce ailment when accumulate in the tissues of living organisms via food chain. Therefore, its removal from the industrial effluents is necessary. The present experiment was conducted to remove Cr from tannery wastewater by using three different forms of rice husk (RH-biochar, RH-compost and RH-raw). Effects of altered pH (4, 6 and 8), contact time (1, 4 and 19 h) and dosages on Cr removal by rice husk were studied. Maximum removal of Cr (99.9\%) was observed by 0.5 g of compost at contact time of 19 h, pH 8 and temperature 28 °C followed by removal efficiency of RH-raw waste. The results revealed that RH-biochar has minimum sorption efficiency for Cr as compared to RH-compost and RH-raw waste material.

**Key Words:** Chromium, Ricehusk, sorption, compost, biochar
Aquaculture has vigorous role in socio-economic development of a country and contributes to its national economy via employment, gross domestic products, food security and foreign exchange earnings. Increased industrialization and urbanization discharge huge amount of toxic matters in environment causing hostile effects on fish and other biota in ponds by altering their natural environment. Fish have been extensively used as a model for eco-toxicological research. A study was conducted to critically examine the pollutants effecting fishponds and controlling approaches of pond contamination. Organic, chemical and thermal pollutants including pesticides, detergents, oil dispersants, heat, radioactive substances, heavy metals, and soil erosion have abrupt and catastrophic effect on fish population. Physical (aeration, hydrological manipulation, mechanical mixing, dessication, surface skimming and ponds digging), chemical (Algaecides, barley straw, coagulation/flocculation and hypolimnetic oxygenation) and biological techniques (Floating artificial wetlands, reed beds, and submerged plants) and their efficiency to control the pond pollution has appraised in this study. It has been deliberated that biological and physical approaches are more auspicious as compared to chemical methods to treat fishponds due to adverse effects of chemicals on fish and other biota in the fishponds.

**Key Words:** Aquaculture, fish, pond pollution, eco-toxicological
EXPLORING THE EFFECT OF CONSORTIA USING DIFFERENT PLANT SPECIES AND BIOSORBENT-EMBEDDED BEDDING MEDIA IN CONSTRUCTED WETLAND TECHNOLOGY FOR TREATMENT OF ARSENIC-CONTAMINATED WATER

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Groundwater arsenic (As) contamination is an emerging issue worldwide especially in Southeast Asian countries. Arsenic is classified as class-I human carcinogen. To remediate As-contaminated water there are many approaches which includes chemical, biological and physical methods but, these are expensive and not adoptable in developing countries due to certain limitations. Constructed wetlands (CWs) can play an efficient role in remediation of contaminated groundwater and wastewater. Constructed wetlands offer a land-intensive, low energy, and less operational requirements alternative to conventional treatment approaches, especially for developing communities. The objectives of this study were to (1) assess the potential of Common reed (Phragmites australis) and Cyprus (Cyprus roduntus) in vertical flow CWs (VF CWs) to remove As from contaminated water, and (2) explore the potential of biosorbent-embedded bedding media (B-EBM) prepared from orange peel and sugarcane bagasse to enhance the CWs efficiency. Constructed wetlands were setup in the wire house. Two different wetland plant species were planted in the CWs to explore their efficiency to remediate the As from As-contaminated water. Biosorbent-embedded bedding media was applied to the CWs to unveil how much it enhances the CWs efficiency. Arsenic (as sodium arsenate) solution was applied at 100 mg/L. The biosorbent-embedded bedding media was efficient to remove 83% of As while common reed and cyprus enhanced the efficiency of As removal using CWs upto 85% and 87% respectively in combination with B-EBM. It can be concluded the constructed wetland technology and biosorbents as embedded bedding media may be an efficient method to remediate As from the contaminated water.

Key Words: Arsenic, Cyprus, Common reed, biosorbent
SOIL-MICROBE-PLANT INTERACTION FOR SUSTAINABLE ENVIRONMENT

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Global climate change is the major restriction against the sustainable agro-ecosystem. With the increasing population the demand of food is increases many folds but supply is not enough to fulfill the increasing requirement due to drastic variation in climate. Proper Management of the scarce resources are essential for sustainability because agriculture sector is facing severe damage due land degradation, intensive agriculture, water scarcity and more prone to biotic and abiotic stress. Plant – microbe relation is considerably effective approach to tackle the productivity issue by promoting plant growth significantly. Beneficial soil micro-biota stimulates plant growth, confer resistance against biotic and abiotic stress and assist plants for reinvigoration of degraded soil. Unpredictable nature and wide spread distribution of microbes enables the plants to survive under adverse climatic condition. Enhance plant growth by mineralization of nutrients, increase their bio-availability, improving physiochemical properties of soil by secreting root exudates that contain various minerals, vitamins and organic acids, among them PGPRs are more widely used due to their high efficacy that promote plant growth both direct and indirect ways. Agricultural activities result in environmental contamination due increase use of chemical additives, pesticides, release of organic pollutants incineration of waste that degrade the quality of air and soil. Employ the microbe base eco-friendly agricultural practices such as biostimulation, bioaugmentation, biofertilizer and biopesticide that enhance crop productivity, generate less pollutants and maintain sustainability of Environment.

KeyWords: Climate change, Sustainability Issue, Beneficial Soil-microbe-plant interactions
OPTIMIZATION AND CHARACTERIZATION OF LIPOPEPTIDE BIOSURFACTANT FROM *Bacillus licheniformis*

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Biosurfactants are biologically active compounds produced by different microbial strains having hydrophilic and hydrophobic moieties. They are best known for their ability to reduce surface tension and help two immiscible solvent to dissolve properly by reducing their surface tension. They are best competitor of synthetic surfactant in term of safety, low toxicity, high biodegradability and eco-friendly nature. Biosurfactants present various applications as emulsifiers, conditioners, cosmetics and food industries. In this study, fruits waste was utilized as cheap carbon source to produce biosurfactant from *Bacillus licheniformis*. The biosurfactant yield was optimized using response surface methodology (RSM) under central composite design (CCD). Maximum biosurfactant production of 36.62 ul/mL was obtained at pH 7, temperature 35 °C, inoculum size 2.25 mL and fermentation period of 96 hours with an emulsification activity of 0.453 at OD\(540\) and emulsification index of 41.07%. This is an efficient method to produce eco-friendly, surface-active compounds and can help to overcome environmental pollution.

**Key Words:** Microbial biosurfactants, Fermentation, *Bacillus licheniformis*, Emulsifiers.
BIOCHEMICAL ASPECTS OF MICRONUTRIENTS AND HUMAN

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Micronutrients including vitamins and minerals play a central role in body metabolism, maintain ace, and proper functioning. The nutritional health of human is total dependent on plant foods directly or indirectly which are excellent source of micronutrients and other phytochemicals. Micronutrient function as anti-oxidant protect cell from damage, strengthen immune system, and prevent from many diseases including diabetes, cancer, stunt growth, and osteoporosis. An adequate intake is important to maintain body healthy. Less intake causes malnutrition and when we consume in excess amount it causes toxicity. Adults are mostly considered to suffer from malnutrition due to inadequate intake of micronutrients and are at risk of malnutrition. These deficiencies are highly prevailing in low- and middle-income countries, effecting the risk of illness, and death from various infectious diseases by reducing immune system. Most common targeted individuals are children, pregnant and lactating woman’s with iron and calcium deficiencies all over globe. Hence to prevent all these sufferings we should have diet rich in micronutrients including high ratio of vegetable, fruits and dairy products. Use of supplements is primary method to reduce micronutrients deficiency. Moreover, certain food enhances the absorption of another food for example, we can eat foods contain vitamin C with iron containing foods and also calcium for absorption of vitamin D. It will make a combination of many efforts such as gardening, selective breeding, fortification, and food perpetration.

Keywords: micronutrients, anti-oxidants, malnutrition
DELETERIOUS EFFECTS OF ARSENIC CONTAMINATION ON PENICILLIUM SURVIVAL

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The research was performed at Botany department, Nusrat Jahan College Rabwah Pakistan to examine detrimental effects of arsenic stress on penicillium extracted from decayed orange. Different concentrations of sodium arsenide (1mg/L, 2mg/L, 3mg/L, 4mg/L, 5mg/L, 6mg/L, 7mg/L, 8mg/L, 9mg/L and 10mg/L) were applied to penicillium grown on CLED media to determine zone of inhibition through disk, well and spread method. Stress applied and control (without arsenic stress) petri plates were incubated for 24 hours at 37°C. After incubation zones of inhibition were measured. Our study has shown that penicillium growth has been adversely inhibited with increase in arsenic stress.

Key Words: penicillium, arsenic, CLED, well method, spread method, disk method.
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EVALUATION OF SACCHAROMYCES CEREVISIAE (YEAST) GROWTH 
RESPONSE TO ARSENIC STRESS

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The research was performed at Botany department, Nusrat Jahan College Rabwah Pakistan to determine growth responses of yeast on exposure to arsenic stress. Yeast strain was taken from NARC Pakistan. Different concentrations of sodium arsenide (1mg/L, 2mg/L, 3mg/L, 4mg/L, 5mg/L, 6mg/L, 7mg/L, 8mg/L, 9mg/L and 10mg/L) were applied to yeast grown on CLED media to determine zone of inhibition through disk, well and spread method. Stress applied yeast petri plates were incubated for 24 hours at 37°C. After incubation zones of inhibition were measured. Our study has shown that yeast is not resistant to arsenic stress, with increasing values of arsenic, yeast growth has declined. This reduction of yeast growth due to arsenic stress can pose severe problems for soil and overall plant growth. Hence strong competent measures are required to overcome arsenic issue.

**Key Words:** yeast, arsenic, CLED, well method, spread method, disk method.
ROLE OF RHIZOSPHERIC BACTERIA IN BIODEGRADATION OF GLYPHOSATE AND ITS IMPACTS ON MAIZE CROP

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Chemical herbicides are extensively used for eliminating weeds for sustainable crop production to overcome the food safety and food scarcity issues around the world. Many of these herbicides are characterized as persistent organic pollutants (POPs). Chemical herbicides including glyphosate which poses serious health risk to humans by becoming the part of food chain. Glyphosate is an organo-phosphorus containing compound that has been widely used for the last four decades to control different types of weeds which acts by inhibiting the plant enzymes. It has been used widely to control weeds issues, especially annual broadleaf weeds and grasses that compete with crops for limiting resources including sunlight, water nutrient. Its residual concentration in soil and in water pose serious health effects on living organisms, like endocrine disruption, muscle stiffness and cancer. Different environmental concerns relating to the toxicity of glyphosate and its metabolites demanded attention towards the biodegradation of this herbicide. Different bacteria have capability to degrade herbicide in a wide range of environmental conditions. To evaluate this, an experiment was designed to examine the efficacy of multi-trait bacteria capable of degradation of glyphosate and their efficiency to growth promotion of maize. For this purpose, bacteria were isolated from the soil with the history of glyphosate application. These bacterial isolates were than screened and characterized for plant growth promotion and glyphosate degradation under axenic conditions. The results showed that these bacteria degraded the glyphosate up to the maximum values while these rhizospheric bacteria also promotes the growth of the crop. Rhizosperhcic bacteria can be an efficient way to degrade the glyphosate and to minimize its toxicity symptoms. Also plant growth promoting bacteria can also promote the growth of maize crop.

Key Words: Biodegradation, PGPR, Glyphosate, Health effects.
BIOREMEDIATION OF MUNICIPAL WASTEWATER: A CASE STUDY

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Wastewater generated has become a significant alternative of fresh water if treated properly, which necessitates appropriate management strategies. However, due to complexities associated with wastewater treatment, we still lack of economically viable treatment systems, especially in low and mid-income countries. Bioremediation is the technique, which is economical and energy saving, and thus is prevailing in all over the world. The present study was conducted at Bioremediation Plant in NARC Islamabad. NARC using constructed wetland (CW), which is one of bioremediation techniques, used to treat municipal wastewater (MWW). CW are eco-friendly, cost effective and can be jointly driven by public bodies and communities. Wet lands are less expensive to build and operate than mechanical system. In these systems wastewater is treated by the processes of sedimentation, filtration, digestion, oxidation, reduction, adsorption and precipitation. Within each pond there are aquatic plants, soil substrate and micro-organisms. These all have a great potential to absorb heavy metals, pathogens, nutrients and solids. The study includes hydro-geophysical characterization of CW to determine pollutant removal efficiency and reuse option of treated wastewater for irrigation. Physico-chemical parameters of the samples were analyzed during the study. The results show the removal of organic content (74-82%), nutrients (77-97%), EC (49-54%), TSS (93-99%) and TDS (79-91%) from the wetland treated wastewater and its suitability for agriculture applications. Thus, the study shows that this is an effective technique to treat the MWW and this can help to treat MWW which can be used for irrigation in Pakistan in future.

Keywords: Wastewater, Treatment, Constructed wetland, Bioremediation
World agricultural lands are becoming deficient in micronutrients due to intensive agriculture. To overcome the problem we need to apply micronutrient fertilizers but most of the fertilizers available are highly soluble which leach down in heavy rainfall areas or irrigated land, especially where farmers are adopting flood irrigation practice. Boron (B) is one of those micronutrient whose deficiency ranked second in limiting crop growth after zinc (Zn) worldwide. A study was conducted to formulate B and biochar coated DAP fertilizer by coating B (0.6%) and different levels of biochar 2, 4 and 6% on DAP (diammonium phosphate). An incubation study in lab followed by wire house experiment was conducted using complete randomized design with three replications. During soil incubation study, extractable P and B were analyzed with 10 days interval. The physiological and growth parameters of soybean were also determined. The results of soil incubation study showed that P and B from coated DAP were uniform with slight difference after each 10 days of analysis as compared to control and results of wire house experiment shows significant increase in physiological and growth parameters as compared to control which could be due to combined application and appropriate supply of B and P.

Key words: Boron; DAP; Biochar and Coating.
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REMEDIATION OF NICKEL CONTAMINATED SOIL BY BRASSICA

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Due to rapid industrialization and urbanization the heavy metal contamination is an emerging issue for the developing countries including Pakistan. Heavy metals enter into environment both by natural and anthropogenic activities. Nickel contamination in the environment is becoming a serious threat due to its entry through metal plating industries, nickel mining, combustion of fossil fuels and electroplating. Through various mechanisms of its release from different sources it can enter into our food chain thus causing a disturbance in the sustainable agriculture approaches. High concentration of Ni causes different health effects like skin disorders, respiratory issues and ultimately leading to the caners of various organs. The objective of study was to explore Ni accumulation and tolerance by two species of Brassica (Brassica Juncea and Brassica carinata) in an artificially Ni contaminated soil. Brassica juncea (T-59) was grown on artificially contaminated soil to observe its tolerance. EDTA and chelating agent was used to enhance the metal uptake at flowering stage. Among both species of Brassica family, Brassica juncea was highly tolerant and uptake more Ni. Among four cultivars (TM-2, TM-4, RH-30, T-59) of Brassica juncea, T-59 was highly tolerant to Ni toxicity based on tolerant parameters. During two months of cultivation it accumulates a maximum amount of Ni in its roots and shoots from soil. The results showed that Ni contamination can be remediate by Brassica species along with EDTA in both Brassica species. The research study indicated that Brassica juncea was more tolerable to Ni contaminated soil and has the potential to be hyperaccumulator of Ni. This study concludes that Brassica juncea can be an alternative phytoremediation approach to remediate Ni contaminated soil.

Key Words: Remediation, Nickel, Toxicity, EDTA
SUNFLOWER (*HELIANTHUS ANNUUS*) TOLERANCE TO WATER DEFICIENCY AS AFFECTED BY FOLIAR APPLICATION OF POTASSIUM

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Sunflower (*Helianthus annuus*) is an oil seed crop and accounts as world’s third largest oil supplier after soybean and groundnut. Due to the shortage of water the production of sunflower is much lower than its potential in Pakistan. Like other plants, sunflower is very sensitive to water deficiency during the reproductive phase, resulting in a significant reduction in crop yields. A field experiment was conducted to observe the response of foliar application of potassium in drought condition. During water shortage foliar application of potassium was applied at vegetative and reproductive stages of sunflower as compared to the control. Result showed that foliar application of potassium performed much better in respect to control on both stages of sunflower. Results revealed that plant height, leaf area, stem diameter, head diameter, achene yield and oil content can be increased by foliar application of potassium as compared to control condition. It is concluded that foliar application of potassium is an effective approach to ameliorate the moisture shortage in sunflower.

**Key Words:** Drought stress, Foliar application of potassium, Biological yield, Economical yield, Sunflower.
COMPARATIVE POTENTIAL OF PRECURSORS OF PLANT GROWTH REGULATOR ON THE GROWTH PROMOTION OF MAIZE CROP

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Exogenous application of plant growth regulators as growth stimulator is an important element in modern day crop production technology to improve yield and growth of most crops in different parts of world. Response of exogenous application of Indole acetic acid (IAA) and L-Tryptophan (L-TRP), a precursor of auxin, was evaluated on the growth and yield of Zea mays through a pot experiment. The crop was evaluated in the presence of three different levels of L-TRP (10⁻⁴, 10⁻⁵ and 10⁻⁶ M) and IAA (10⁻⁴, 10⁻⁵ and 10⁻⁶ M) for improving the growth and yield of maize crop and compare them against untreated control. Maize seeds were soaked in L-TRP (10⁻⁴, 10⁻⁵ and 10⁻⁶ M) and IAA (10⁻⁴, 10⁻⁵ and 10⁻⁶ M) solutions respectively and sown following Completely Randomized Design (CRD) with three replications each. The results obtained were statistically analyzed and pronounced effects of L-TRP and IAA application was observed on all the growth and yield parameters. Among the treatments applied, treatment T₃, L-TRP (10⁻⁵ M) and T₆, IAA (10⁻⁵ M) gave the most promising results and significantly increased the root length, shoot length, root mass, shoot mass and Chlorophyll contents as compared to untreated control. Our results highlight that treating seeds with L-TRP and IAA could be a useful approach for improving growth and yield of maize crop.

Keywords: IAA, L-TRP, maize, plant growth regulator
RESPONSE OF PHYSIOLOGICAL AND BIOCHEMICAL ATTRIBUTES OF CUCUMBER GENOTYPES BY THE FOLIAR APPLICATION OF CHITOSAN UNDER FIELD CONDITION

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Production of summer vegetables is tremendously influenced by elevated temperature overhead thresh hold level. To save cucumber against drastic effects of heat stress a study was designed to evaluate physiological and biochemical response of chitosan in cucumber genotypes under three sowing dates. Four cucumber genotypes, two tolerant (L3466 and Desi-cucumber) and two susceptible (Suyo Long and Poinsett), screened out in the previous experiment were sown in vegetable research area of Institute of Horticultural Sciences, UAF during 2016. The first sowing was done on 15th March, followed by 1st April and 15th April, respectively with four replications. Chitosan @ 200 ppm was applied as foliar spray on 30 days after emergence of seedling and then two times after a week interval. During present research, summer temperature was maximum recorded 47.5°C, 48°C and July 46.1°C in May, June and July respectively. Chitosan treated plants in all genotypes improved the enzymatic antioxidants and osmolytes in enhancing the ability of plant to tolerant heat stress. Improvement in physiological (photosynthetic rate, transpiration rate, water use efficiency) and biochemical characteristics (SOD, POD, CAT and protein contents) were observed in chitosan treated plants as compared with non-treated plants in cucumber crop. It was revealed that heat tolerant cucumber genotypes showed more response to chitosan application as compared to heat sensitive ones.

Key Words: cucumber, chitosan, morphological, biochemical, sowing dates
ACCUMULATION OF POTENTIALLY TOXIC ELEMENTS IN TOMATO (Lycopersicum Esculentum L.) CROP BY THE APPLICATION OF SEWAGE SLUDGE

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Sewage sludge (SS) is generated as a byproduct during the treatment of wastewater. Being organic waste, SS is a good source of plant nutrients such as nitrogen (N), phosphorus (P) and potassium (K). High levels of toxic trace elements such as cadmium (Cd), chromium (Cr), copper (Cu) nickel (Ni) and lead (Pb) may also be present in SS. It may have the potential to enhance the crop yield but entry of trace elements in food chain is also a big threat. The pot experiment was conducted to achieve the accumulation of trace elements at various SS application rates and the suitability of the use of SS for tomato plants by evaluating growth, biomass and yield responses. Three levels of SS (0.5%, 1.0% and 1.5% w/w) were soil applied (collected from I-9 sector, Islamabad waste water treatment plant, ISS). Control treatment (without SS) was included to compare the effect of treatments with SS amendment. Two weeks old seedlings of tomato (Lycopersicon esculentum L.) variety Sahel Syngenta was transplanted into the pots. The results showed that growth and physiological parameters of tomato remained better at lower application levels of SS. High rate of SS caused reduction in growth and physiological parameters. Shoot and root fresh weight, root/shoot length, number of flowers and chlorophyll contents were the lowest at ISS1.5% level. Concentration of trace elements (Cd, Cu, Ni and Pb) in shoot and fruit of tomato was increased with the increasing rate of SS and the lowest in control. The concentrations of Cd, Ni and Pb in shoot and fruit of tomato were recorded well above the FAO/WHO critical limits (10, 0.05, 0.5 µg/g, respectively) with ISS1.5%. It was concluded from the results that ISS can be used for vegetable production like tomato but at lower rate to avoid trace elements contamination in the food chain.

Key Words: sewage sludge, toxic metals, tomato, bioaccumulation
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BIOLOGICAL TREATMENT OF TEXTILE WASTE WATER IN FAISALABAD USING THE AQUATIC PLANT, WATER HYACINTH

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The burning issue of the present time in the industrial city of Pakistan, Faisalabad due to its massive population and industrialized survival is the serious environmental ailments caused by waste water pollution. The main source of its production through industries that contain many contaminants like dyes, degradable organics, inorganic salts, stabilizing agents, heavy metals, desizers and detergents. Many methods are adopted to remove the contaminated or polluted compounds from the waste water which include chemical, physical, biological and other combined methods with the help of different technologies. The present overview was intended to treat the waste water via biological method which use a floating aquatic weed, water hyacinth (Eichhornia crassipes). The sample of surface water was first collected and then examined for water quality input parameters including pH, temperature, dissolved oxygen, electrical conductivity, TDS and turbidity. The evaporation and transpiration rate were measured with the lysimeter and after 4 days it was observed that out of 51 liter the evaporation rate was 3.64 liter and the transpiration rate was 1.87 liter. So, within 24 hours the rate was 0.91L and 0.47L respectively. The outcomes clearly indicate that out of all the parameters TDS and turbidity values exceeds the standard NEQs values which reflects the fact that surface water is highly polluted, and its treatment is mandatory in order to minimize health issues in Faisalabad. So, it is need of time to take firm steps to make sure that wastewater is treated before discharge into channel so that water contamination can be diminished, and treated water can be used for useful tenacities. Proper awareness regarding the water pollution and the use of appropriate waste water technologies must be given to the people for better future.

Keywords: Industrialization; Waste water; Input parameters; water hyacinth; Lysimeter; evaporation rate; Transpiration rate.
COMPARATIVE RESPONSE OF DIFFERENT WHEAT CULTIVARS TO VARIOUS FORM OF NICKEL IN ROOTING MEDIUM

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Earth crust comprises various heavy metals naturally. Heavy metals may enter our bodies by different ways such as respiration, drinking water and eating food. Some heavy metals are trace elements and needed to maintain good metabolism of plants or human body. In the atmosphere, the concentration of Ni has been surprisingly increased due to anthropogenic and natural activities. Small amount of Ni is needed to plants for their normal metabolic and physiological process but, high concentration of Ni having adverse effect on plant growth. Wheat is the main source of food and nutrients among the cereals crop in Pakistan. The basic purpose of this research was to check the impact of different salts of Ni in the nutrient solution on the development and biochemical characteristics of different wheat cultivars (*Triticum aestivum* L). Three wheat varieties Fsd-2008, Punjab-2011 and Ujala-2016 were grown in hydroponic with two sources of Ni; NiSO₄ and Ni-acetate with different concentration. Interactive effect of organic and inorganic form of Ni on different parameters of wheat like fresh weight of shoot, fresh weight of root, shoot length, root length, dry weight of roots and dry weight of shoot, concentration of Ni in shoots and Ni concentration in root, Ni uptake in shoot and root and chlorophyll content were examined in three wheat varieties. The results shown that different salts of Ni reduced the growth of wheat. Organic form of Ni enhanced the uptake capacity of Ni in shoots and roots as compared to inorganic form. It was useful to assess the toxicity effects of Ni on the biochemical and physiological constraints of wheat.

Key Words: Heavy Metals, Nickel Toxicity, Wheat,
RESPONSE OF MAIZE CROP TO DIFFERENT P-SOLUBILIZING ISOLATES

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Maize is an important crop in temperate climate region as well as semi-arid climate region, because of the increasing demand of food and livestock feed. Plant growth promoting bacteria may be important for plant nutrition by increasing N and P uptake by the plants and playing a significant role as PGPR in the biofertilization of crops. Bacterial inoculants are able to increase plant growth, speed up seed germination, improve seedling emergence, responses to external stress factors, protect plants from diseases and root growth pattern. Strain of Pseudomonas fluorescens and Pseudomonas putida could increase root and shoot elongation in canola as well as wheat and potatoes. This experiment was conducted in growth room of the Soil Bacteriology Section, Ayub Agriculture Research Institute (AARI), Faisalabad, Pakistan in order to explore the effect of P-solubilizing microbes (Bacillus and Pseudomonas) on growth and yield of maize (Zea mays L.). Under growth room condition, selected culture of P-solubilizing microbes were applied as seed treatment. The experiment was harvested after 7 days. Result showed that root and shoot length (cm), biomass of root and shoot (g) and chlorophyll content (mg/g) clearly increased by using P-solubilizing microbes (Bacillus and Pseudomonas) compared to control. The study that is described here indicate the potential use of P-solubilizing microbe for the growth promotion of maize.

Keywords: Bacillus, Pseudomonas, maize, growth promote
CARBON SEQUESTRATION AND ENVIRONMENTAL GREENING OF DEGRADED AGRO-ECOSYSTEMS

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Carbon dioxide (CO₂) is the most commonly produced greenhouse gas. It is produced from use of fossil fuels for energy production in industries, power plants and vehicles. CO₂ induced climate change effects on agriculture from loss of productivity, microbial diversity, organic matter in soil, drought, shifting of agro-ecological zones, loss in crop yield to even disasters like food security problems; other effects on environment includes extreme weather events like floods, intensive rains and storms, forest fires, sea level rise, loss of biodiversity and habitat loss. Due to the harmful effects of CO₂, different strategies are being used and developed to store it in its sinks rather than to allow its entry to atmosphere and face global warming and climate change. These methods include carbon sequestration, afforestation/reforestation, carbon farming, biofuel production, biochar production, ocean fertilization, rock solutions to capture CO₂, direct capture from air and the latest method of using cerium metal nanoparticles to capture CO₂. Carbon sequestration one method of reducing the amount of CO₂ in the atmosphere and storing it in soil and plants with the goal of reducing global climate change. To sequester CO₂, degraded soils can also be used by using well established reclamation techniques. By using degraded soils for this purpose has many benefits like more area could be under the crop cultivation, more food production by using these soil means less food security problems, economic benefits to farmers, more CO₂ will be sequestered in soils enhancing the soil and crop productivity which is a win-win strategy.

Keywords: Carbon sequestration, degraded soils, Soil reclamation, Amendments
INFLUENCE OF BIOCHAR ON PLANT UPTAKE AS SOIL AMENDMENT IN AGRICULTURE FIELDS: A CRITICAL REVIEW

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In nutrient deficiency lands and contaminated soils, biochar has become a good option for soil management, which is now become a global issue in recent years. Increasing depletion of soil nutrients which lead to deficiency of plant nutrients reported globally. Biochar contain high carbon content and range of plant micro and macro nutrients. Role of biochar on plant nutrient uptake crucially influence by the biochar physical microstructure determining the assessment to mineral elements by microorganisms, roots of plants and soil solution. Biochar porous nature provides habitat for beneficial microorganisms which include bacteria and mycorrhizae. In the terms of improved soil quality and increase in crop production due to valuable use of biochar as soil amendment reported. The biochar amendment increases the soil pH, total nitrogen, soil water holding capacity and organic carbon of soil. The addition of biochar in the soil can increase the activity of microorganism population which can affect the availability of Manganese which is a micronutrient for plant growth by alternate the microorganism activity and population. Biochar induce soil water permeability and the amount of water which available for plants. Biochar is an ideal embedment for metal retentivity, this can impose impacts on plant uptake. Biochar can be different in composition and the nutrients availability depend on biomass and pyrolysis conditions. Nutrients uptake by plants not only directly depend on the nutrients composition of biochar but may indirectly depend on the mechanism between soil and biochar. The Quality parameters of soil are important for biochar performance, interaction of biochar nutrient in soil and status of nutrients in soil which can vary with time.

Key Words: Biochar, Agriculture, Plant Growth, Soil Nutrients
CONTRIBUTION OF ORGANIC MATTER AND RHIZOBACTERIA TOWARDS MAIZE (Zea Mays L.) YIELD AND SOIL HEALTH UNDER HEAVY METAL CONTAMINATED CONDITIONS

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Since the start of industrial era heavy metals have been great threat to the environmental sustainability. Anthropogenic activities are the main sources for their entrance into the soil and plant environment. They effect crop growth by disturbing soil structure and soil health. This study was planned to check the effects of organic matter and rhizobacteria on the yield of maize and metal contaminated soil health. Experiment was in the glass house of Institute of Soil and Environmental Sciences (ISES), UAF under completely randomized design (CRD), soil was artificially contaminated with two level of Pb (100 and 200 mg kg⁻¹), one level of organic peel (7.5 g kg⁻¹) and PGPR was applied in the form of seed inoculation. Citrus peel was used as a source organic matter and rhizobium species of PGPR were coated on the seed of maize. These PGPRs produce indole acetic acid and gibberellic acid in the culture which act as a soil conditioner, improve soil structure and decrease the runoff. Combination of organic matter and rhizobium also suppress the activity of heavy metal and lessen soil contamination by the process of bioremediation. Rhizobium species also act as P-solubilizer, modulators and N-fixers so providing essential nutrients for better growth and development. Results clearly revealed that plants height (cm), number of leaves, leaf area index(cm²), chlorophyll contents, and grain yield (kg per pot) and dry mass of the crop was better in the treatment where organic matter was applied with inoculation of rhizobium species. Combined effect of organic matter and rhizobium improved soil structure and increased the maize yield.

Key Words: Organic matter; rhizobium species; soil conditioner and heavy metal
EFFECT OF ORGANIC AMENDMENTS ON GROWTH AND YIELD OF OKRA UNDER SALINE CONDITIONS

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Soil salinity is a major factor contributing to the loss of crop growth and productivity. Okra is a highly nutritious crop and provides protein, minerals, amino acids, vitamin A, B, C and iodine. Soil applications e.g. compost and biochar are used to minimize the negative effects of salinity on plant growth. To evaluate the effects of compost and biochar on okra under saline conditions, an experiment was conducted in a wire house, Institute of Soil and Environmental Sciences, University of Agriculture Faisalabad with completely randomized design. There were two salinity levels (5 and 8 ds m\(^{-1}\)) along with control. Biochar and compost were applied at 1% on soil basis alone and in combination with each other. At maturity stage plants were harvested. Growth parameters e.g. plant height, fruit weight, chlorophyll content, membrane stability index and relative water content were determined. Data was determined by appropriate procedure. Results indicated that plant growth was improved by the application of biochar and compost. However, the combine application of biochar and compost proved more effective in eliminating harmful effects of salinity.

Key words: Biochar, compost, okra, salinity, chlorophyll
COMPARATIVE POTENTIAL OF DIFFERENT ENDOPHYTES FOR GROWTH PROMOTION OF MAIZE CROP (*Zea mays L.*)

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Maize is the major food source and is a high yield commodity crop. In world production, maize is ranked as the third cereal crop after wheat and rice. Manipulating growth of plant by using different beneficial endophytic cultures offer a great promise for promotion of Maize crop. Bacterial endophytes are predominant population inside plant tissues and have been shown to serve plant growth and health. Endophytic bacteria improve plant growth by two ways directly and indirectly. Production of plant growth regulators, phytohormones (Auxins, Cytokininv, and Gibberellins), specific enzymes, endotoxins (having insecticidal properties), Solubilization of insoluble phosphate from the soil and iron chelating siderophore production are direct ways to improve growth. While characteristics of endophytes which improve plant growth through biocontrol of plant disease & production of antibiotics are indirect ways. A pot study was conducted at Soil Bacteriology Section, Ayub Agricultural Research Institute, Faisalabad, Pakistan in order to explore the effect of endophytes on growth and yield of maize (*Zea mays L.*) crop. Five different endophytic cultures were prepared regarding to their potential ability to stimulate or boost the plant growth. Under glass house conditions, all the selected cultures of endophytes were applied as seed treatment. The experiment was laid out in completely randomized design (CRD). Results showed that root and shoot length (cm), fresh biomass of root and shoot (g), IAA Equivalents (µg/ml) and chlorophyll contents (mg/g) were significantly increased by using endophytic cultures compared to the control. Endophytic culture treatments showed the highest positive effects on plant growth parameters.

This paper describes the potential use of different endophytes for growth promotion of maize crop.

Keywords: Endophytic, IAA, maize, plant growth regulators
EFFECTS OF HEAVY METALS AND THEIR REMEDIATION ON SOIL SURFACE, CROP PRODUCTION AND ON HUMAN BEINGS

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Globally there are over 20 million ha of land contaminated by the heavy metals like As, Cd, Cr, Hg, Pb, Co, Cu, Ni, Zn, and Se, with by anthropogenic activities. Heavy metal contamination of soils resulting from mining and smelting is causing major concern due to the potential risk involved. This study was designed to investigate the heavy metal (Cu, Zn, Pb and Cd) concentrations in soils and food crops and estimate the potential health risks of metals to humans via consumption of polluted food crops grown under CRD at Government College University, Faisalabad. The issue of heavy metal pollution is very much concerned because of their toxicity for plant, animal and human beings and their lack of biodegradability. Heavy metal contamination of food crops grown around the mines posed a great health risk to the local population. Various plant species are used for phytoremediation of these heavy metals. The application of PGPR as bio-fertilizers and atmospheric nitrogen fixer contributes considerably to the intensification of the phytoremediation process. Different experiment was conducted under different condition to check the soil toxicity and crop production. After using synergistic effects with plant growth promoting rhizobacteria (PGPR) soil and plant growth shown significant results. Results also revealed that these practices proved to be environmentally friendly.

Keywords: Heavy metals; land contaminated; toxicity; crop production; phytoremediation and plant growth promoting rhizobacteria.
DIFFERENTIAL GROWTH RESPONSE AND DISTRIBUTION OF NICKEL IN DIFFERENT PARTS OF THREE WHEAT CULTIVARS

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Accumulation of heavy metals is one of the grimmest environmental concerns, not only because many of these metals are toxic to the crops themselves, but also because of their potential harm to humans and animals. Nickel (Ni) is present in the environment due to different anthropogenic activities. The purpose of this study was to assess the Ni contamination and its possible remedial measure in plants. Three varieties of wheat Fsd-2008, Punjab-2011 and Ujala-2016 were used in this experiment. In experiment, five treatments of Ni application 5, 10, 20, 40 and 80 mg L⁻¹ were used. The effect of Ni application on different parameters like shoot and root length, fresh weight of root and shoot, dry weight of root and shoot, chlorophyll content, Ni concentration in root and shoot and Ni uptake in root and shoot in different wheat varieties were examined. Ni toxicity reduced the different growth parameters. As the Ni concentration was increased, the productivity of wheat was decreased. On contrary to this, Ni uptake and concentration was increased by increasing the concentration of Ni in the medium. At lower concentrations Ni uptake was less as compared to higher concentrations. Ni was more accumulated in the root than in shoots. It was suggested that, if Ni was applied in lower concentration then it can be beneficial to plant, while toxic at higher concentrations in our soils.

Key Words: Heavy Metals, Nickel, Wheat, Toxicity
TECHNOLOGICAL ADVANCEMENT IN BIOCHAR AND ITS INFLUENCE ON AGRICULTURE SECTOR

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Agriculture sector may the most contributing factor in economy of the any country. If we talk about the productivity and management of the agriculture field then biochar is major and key component of the soil. It play very vital and significant role in the proper management and productivity of the Soil. There are different types of the biochar which is manufactured by different biomass materials such as wood waste, animal manure, dead plants, crop residues and other organic waste etc. Biochar contains the high concentration of the nutrient (carbon, nitrogen, phosphorus, calcium, sulphur, potassium and other micronutrients). The concentration of all the nutrients may vary in biochar due to biomass material. Today, the biochar is produced through innovative technologies by nanoparticles. By the using of nanoparticles into biochar, the functions of the biochar has been improved for the many applications such as in soil management and fertility enhancement of the soil. This type of biochar having more capability in the growth of crops rather than other types of the biochar and play very crucial role in the early development of the structure and roots of plants. Nano material biochar having more efficiency in the remediation of contaminated soil and to increases the nutrition availability, cation exchange capacity and water holding capacity in agriculture field and having more stability and availability of nutrients than other amendments of soil. The use of this type of biochar can be useful to maintain the quality and pH of soil.

Key Words: Agriculture, Biochar, Technology, Nutrients
Dilemma of heavy metal pollution in soil due to anthropogenic influences has become crucial to resolve. Among trace metals, lead (Pb) is a highly toxic pollutant, being perilous to humans and animals. Phytoremediation is a type of technologies that use plants to eliminate, reduce, or restrain the contaminants. This technique is well-suited for use at very large field sites, cost-effective and practicable as well. More than 400 plant species have been recognized as the prospective phytoremediators. The aim of current study is to inspect the Pb effect on biomass and accumulation potential for three species of plants Zea mays, Sesbania sesban, and Sorghum bicolor. For this study collected seeds of maize, sorghum, and sesbania were sown in pots filled with sandy loam soil. The pots were arranged in a completely randomized design with four replicates. After one week of seed emergence, experimental treatments of different lead chloride (PbCl₂) solutions with concentrations of 5 ppm, 10 ppm, and 15 ppm Pb and a control treatment with no Pb, were applied to respective pots once in a week. Past studies elucidates that Pb acts as growth inhibitor for plants. In this recent study under these conditions, it was observed that maize and sorghum showed rapid growth as concentrations increased (15 ppm> 10 ppm> 5 ppm> control) of experimental treatments, even cob grew first in those plants which were treated with 15 ppm while sesbania didn’t show such change in growth. At maturity, plants were manually harvested and each plant was dissected into different parts i.e. roots, stems, leaves, and grains. For sampling after washing, drying and grinding procedure, digestion with aqua regia took place. Zea mays, Sesbania sesban, and Sorghum bicolor have been proved as effective for phytoremediation of soil and can contribute to save environment from cancer of pollution.

**Key Words:** Phytoremediation, maize, soil pollution, sorghum, lead (Pb), growth rate.
SOIL MICROBES-PLANT INTERACTION FOR SUSTAINABLE ENVIRONMENT

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Soil microbes play a vital role to enhance soil fertility. Being inhabitant of soil, these microbes have established beneficial interaction with plants which have led to sustainable environment. Interactions between plants and soil microbes play an important role in structuring ecosystems by influencing plant growth and competitive ability. Abiotic conditions such as varying nutrient levels or environmental stress can alter the direction and magnitude of plant–microbe interactions. For example, when temperature increase in environment soil microbes cannot survive and died. On the other hand, when there is more humidity in surrounding, humid environment provides suitable condition where soil microbial population multiples. Soil microbes have established symbiotic relationship with plants. Nitrogen fixing i.e. Rhizobium lives in root nodules of leguminous plant. Symbiotic nitrogen-fixing bacteria invade the root hairs of host plants, where they multiply and stimulate formation of root nodules, enlargements of plant cells and bacteria in intimate association. Within the nodules the bacteria convert free nitrogen to ammonia, which the host plant utilizes for its development. This useful relationship leads to sustainable environment, where plants gets its nitrogen fixed from bacteria, and bacteria get shelter there.so it is a type of mutualistic relationship in which both get benefit. There is such sort of interaction also where plant also suffers. fungi are an enormous threat to plant health. While a lot of plant-pathogenic fungi are highly host-specific. Biotrophic plant-pathogenic fungi live in close proximity with the plant because they feed on living plant tissue and have to invert the defense systems of the plant. One of their strategies for survival in the hostile plant tissue environment is the secretion of effector proteins that interact with plant proteins to the advantage of the pathogen. In this way plant microbial interaction exists our surrounding.

Keywords: Microbes, Nitrogen fixing bacteria, interaction
REMEDIATION OF LANDFILL SITES BY USING NANOTECHNOLOGY- A REVIEW

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Use of nano-structured materials for the remediation of landfill sites provides one of the cost effective solutions. Nanoparticles ranges between 1 to 100 nanometers and having properties like large surface area to volume ratio and high surface reactivity. These properties are used for the detoxification and also for the deformation of a wide range of contaminants at hazardous waste sites. This technology have potential for mitigation of hazardous pollutants at landfill sites and also chemical reduction. The common nano materials used for remediation at field level are nano-scale zero-valent iron (nZVI), nano-tubes, some noble metals, different fibers and enzymes. Nano-scale zero-valent iron (nZVI) is most widely used and its properties can modified by using different methods like use of catalysts, coatings etc. Application method of nanoparticles depends on the specification and geology of site where it will be injected. Creating nano-scale zero-valent iron (nZVI) on-site results in reduction of reactivity loss. Main advantages of this technique are that there is need of pumping of water above the ground surface for treatment purpose, no transportation of soil, cost effective technology, ability to diffuse through very small spacing because of very minute size of nanoparticles and its innovative coating that allows wider distribution of nanoparticles. However to avoid adverse impact on environment and human health, optimization and proper evaluation of nanotechnology which is using for site remediation must be done.

Key Words: Nanotechnology, Landfill Sites, Remediation, Nano-materials
GROWTH AND YIELD RESPONSE OF SOYBEAN TO CO-INOCULATION OF BRADY RHIZOBIUM AND PGPR

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Soybean is one of the most important annual oilseed crops in the world. Soybean seeds are most important sources of protein and oil in the world. This research was carried out with the objective of to study the influence of PGPR and rhizobium on the growth parameters of soybean. This experiment was conducted out in pots at glass house of Soil Bacteriology Section, Ayub Agriculture Research Institute (AARI) Faisalabad. The experiment was performed as complete randomized design (CRD) with four treatments and three replications. The treatments used in this study were T₁ (Control), T₂ (Azotobactor), T₃ (Rhizobium) and T₄ (Co-inoculation). The pots were filled with soil 1kg per pot. Seeds were soaked with these treatments for one hour and sown 7 seed per pot. Fertilizer were applied according to 100 Kg ha⁻¹ Nitrogen, 60 Kg ha⁻¹ Phosphorous by using urea and KH₂PO₄ after germination. The experiment was harvested after 28 days. Shoot and root length of each replicate was measured. After 7 days, dry mass of shoot and root was calculated. Auxins level was calculated after 14 days and 28 days of sowing. From results it was analyzed that co-inoculation of (Rhizobium+ Azotobacter) performed best results as compared to other three treatments. It was also analyzed that PGPR species considerably increase the biomass of soybean root weight, shoot weight, root length and shoot length as compared to control (T₁).

Keywords: Soybean, Rhizobium, Azotobacter
IMPORTANCE OF MICRONUTRIENTS WITH REFERENCE TO GEONUTRITION AND ITS ROLE IN AGRICULTURE PRODUCTION ALONG WITH LIVESTOCK AND HUMAN HEALTH

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Pakistan is an agricultural country and its soil in cultivated areas have specific qualities like alkaline pH, high calcium and poor in organic matter. These factors are mainly responsible for fixation of micronutrients in the soil and become poorly available for plants. In 1970, a disease called hadda was reported in rice in Pakistan due to deficiency of zinc and further field investigations also reported the deficiency of other micronutrients like iron and boron etc. Zinc is considered as the most deficient micronutrient in the cultivated soils of Pakistan and its deficiency is recorded up to 70%. This deficiency is investigated in major crops like wheat, maize, cotton, potato, sugarcane, brassica along with various fruits like citrus. The deficiency of boron is another important factor which severely damage rice, wheat, cotton, peanut, sugar beet, citrus and other fruits. Iron deficiency comes at third position in the form of iron chlorosis which appears in chickpea, peanut, cotton, citrus and many ornamental tree species. However, localized deficiencies of copper and manganese are also being reported. These mineral elements like zinc, iron and copper are important for human health as these are part of essential organic compounds like proteins, carbohydrates, fats and vitamins and their daily dietary intake is important for proper health maintenance. The deficiency of these micronutrients not only effect the crop production but also hamper their quality. The development of genotypes with efficient micronutrients retaining capacity along with application of fertilizers containing specific deficient micronutrients can overcome these soil deficiencies and resulting livestock and human health problems.

Key words: Agriculture, micronutrients, geonutrition, soil, crops.
INORGANIC ARSENIC: TOXIC & DETOXIFICATION INDICATOR, ITS BIOMARKERS AND MITIGATION STRATEGIES

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Approximately 240 million people in south-east Asia are consuming arsenic at concentrations higher than the threshold levels of 50 μg/L. Age group of less than twenty years are mostly the victims of this toxicity. Chronic exposure, even in sub lethal doses, is creating many health problems in these countries like tumors, cardiovascular disease, polygenic disease and mental health. Methylated metabolites of inorganic arsenic, especially the trivalent forms, are more toxic than the inorganic arsenicals. MicroRNAs reside in protein and non-protein coding regions with their own independent transcription units, do the fine-tuning of gene networks. Transcription leads to a primary miRNA transcript that form hairpin like secondary structures are recognized and excised in the nucleus by DGCR8 and DROSHA, resulting sequence, known as a precursor miRNA, is exported from the nucleus into the cytoplasm by Exportin 5-Ran-GTP. Dicer cleaves the end of the pre-miRNA to produce a double stranded RNA duplex and loads onto the RNA Induced Silencing Complex, at which point the miRNA is ready to guide and tether Argonaute to target RNA sequences, conferring gene silencing by translational repression and/or mRNA degradation. Diabetes at even low-to-moderate exposure levels by dysfunctionality of pancreatic islets, reducing insulin mRNA expression in pancreatic β-cells and suppressing Ca\textsuperscript{2+} influx, inhibiting insulin vesicle packaging and impairing glucose-stimulated insulin secretion can be detected through a list of miRNAs as biomarkers. It also induces a significant Nrf2-mediated antioxidant response, which suppresses endogenous reactive oxygen species that are thought to be involved in insulin secretion, inhibits differentiation of fat cells by decreasing expression of PPARγ resulting in reduced insulin sensitivity and signalling, which play a major role in glucose utilization and energy homeostasis, enhances gluconeogenesis, likely promote hepatic glucose production, disrupts estrogen receptor mediated gene regulation. Arsenic hypermethylates the promoters of 183 cardiometabolic genes, non coding RNAs and DNA of peripheral blood leukocyte, elevates folate. Proofs of microRNAs are still not sufficient to declare arsenic to be a diabetogen and requires further investigation with special emphasis at molecular level. Cost effective water treatment methods and food safety protocols should be developed to nip the evil in the bud. These considerations will be helpful in safeguarding the public health from arsenic-induced problems.

Keywords: Arsenic, Detoxification Indicator, Biomarkers, Mitigation
ASSESSMENT OF SPATIAL SOIL MOISTURE USING GROUND BASED SENSORS AND THERMAL IMAGERY

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Soil moisture is the important parameter to carry out irrigation scheduling at the farm level. However, its measurement in tedious using Traditional gravimetric or Time Domain Reflectometry (TDR) method as the person has to go in the field to determine the moisture conditions. Alternate method is suggested to determine soil moisture at large spatial scale using thermal camera on board Unmanned Air Vehicle (UAV). The soil sample for moisture measurement from an 8 blocks in agronomy field of University Agriculture Faisalabad with two treatments. Having four on ground methods will be applied to determine soil moisture include Gravimetric method, TDR, Electronic soil moisture sensors and simple moisture sensors. The thermal camera also used to determine soil surface temperature using UAV. The temperature is then converted into soil moisture and calibrated using standard Gravimetric method. Different statistics is applied to develop regression equations for different method of soil moisture estimation. It is observed that TDR and electronic soil moisture gives significant result.

Key Words: Time Domain Reflectometry (TDR), Electronic soil moisture sensors, Unmanned Air Vehicle (UAV)
MODELLING THE IMPACT OF CLIMATE CHANGE ON WATER REQUIREMENTS OF WHEAT AND MAIZE UNDER RAINFED CONDITIONS OF PAKISTAN

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Climate change impact on crop production has been rarely analyzed for the diversified climatic conditions of Khyber Pakhtunkhwa in general and D.I. Khan District in particular. Addressing these issues, a scientific analysis was conducted to identify the impact of climate changes on the irrigation water needs (NIR) and crop water requirements (CWR) of wheat and maize crops in D.I. Khan District during four decades (1971-2010). For this purpose, the historical climatic data was grouped into two sub groups (Group-I 1971-1990 and Group-II 1991-2010) and were compared for change assessment. The results indicated an increasing trend for the maximum and minimum air temperature, especially during the months of February, March, April and May, which may tend to increase irrigation water needs for the wheat crop, thus may lead to reduced yield in rain-fed conditions of D.I. Khan. Conversely, the increasing late season precipitation for wheat might have a positive effect on their overall production but reduced early season rains might cause germination problem. For maize crop season the result showed a decreasing tendency in temperature which might support in reducing the irrigation needs of the crop. Importantly, the increasing tendency of precipitation during maize season will also support higher yield, which may be possible through selection liberty of improved seed varieties, which generally demands larger irrigation water. Hence, despite both positive and negative impacts of climate change, increased wheat and maize production are possible through better agronomic management in D.I. Khan.

KEYWORDS: CROPWAT Model, Reference Crop Evapotranspiration, Net Irrigation Requirements of wheat and maize
NITROGEN ADDITION INDUCES THE HEAT TOLERANCE IN WHEAT UNDER A SEMI-ARID ENVIRONMENT

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Nitrogen (N) fertilization plays a key role to boost crop outputs even under adverse environments. The current study was planned to assess the potential of N to ameliorate deleterious effects of HS imposed during vegetative growth period. So, plants of wheat crop were exposed to; (i) elevated canopy air temperature / HS treatment and (ii) control, plants were grown under ambient temperature throughout the growing season. HS and control plants were further treated with 50, 100 and 150 kg N ha⁻¹. Each combination was replicated thrice. The results show that plants under HS treatment accompanied by limited N supply produced highly down-regulated biomass (BM) accumulation, reduced leaf area and limited tillering potential during heat stress period. Furthermore, plants with limited N supply showed lower leaf water contents, Chlorophyll (Chl) contents and higher rupture of plasma membrane. Heat stressed plants exhibited less grains with smaller grain size, greater yield and harvest index reductions. In contrast, higher availability of N ameliorated heat induced penalties to BM accumulation, leaf area and tillering potential of wheat. Heat stressed plants under higher N supply revealed tolerance to heat stress by sustaining higher leaf water contents, membrane stability, Chl contents and final output. Higher application of nitrogen (N₁₅₀) than recommended (N₁₀₀) under normal environment accelerated growth traits, leaf water and Chl contents as well as greater final outputs of wheat. In conclusion, higher N nutrition under elevated canopy air temperature could alleviate the magnitude of penalties to grain yield and enhances heat tolerance capacity of wheat.

Key words: Nitrogen (N) fertilization; heat stress; elevated canopy air temperature
ERADICATION OF AAR-5 DYE FROM POLLUTED WATER USING MUS-ZnO-PANI AND MUS-ZnO-PPy COMPOSITES

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The pollutants that present in the water cause major harms for the ecosystem. Consequently, the exclusion of the dyes is very essential from wastewater. Different methods are available for the removal of dye but one of the best methods is the adsorption method which is very efficient and low-cost treatment. In current study synthesis of hybrid composites MUS-ZnO-PANI and MUS-ZnO-PPy were done for the removal of synthetic dye. Maximum removal of dye AAR-5 using different biosorbents MUS, MUS-ZnO-PANI and MUS-ZnO-PPy observed at optimum pH 2 and their biosorption capacity at 2 pH was 23.345 mg/g, 38.879 mg/g and 40.987 mg/g respectively. Best dosage to exclude the dye AAR-5 in case of different biosorbents MUS, MUS-ZnO-PANI and MUS-ZnO-PPy was 0.05g/ 50 ml at which maximum biosorption capacity attained 28.809 mg/g, 39.654 mg/g and 42.099 mg/g respectively. Equilibrium achieved within 60-90 min for all biosorbents MUS, MUS-ZnO-PANI and MUS-ZnO-PPy and biosorption capacity was 29.998 mg/g, 41.877 mg/g and 43.897 mg/g respectively. Suitable temperature to exclude the dye was observed and that was 35 °C and biosorption capacity at this temperature for MUS, MUS-ZnO-PANI and MUS-ZnO-PPy was 43.187 mg/g, 47.872 mg/g and 50.125 mg/g respectively. Increase in temperature cause decrease in biosorption capability. Langmuir model was best fitted according to equilibrium data analysis. From kinetic modeling pseudo first order reaction and pseudo second order reaction shows satisfactory fitness for removal of AAR-5 dye. Thermodynamic study gave information about the nature, heat content, free energy and feasibility of the occurred reaction.

Keywords: Polyaniline, Polypyrrole, Mustard, hybrid composite, AAR-5
DEGRADATION OF DYE USING MOLYBDATES AND THEIR SULFONATED GRAPHENE OXIDE NANOCOMPOSITE

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Wastewater treatment and pollution are the most critical problems in the present and next generations of people. Wastewater containing dyes has been a serious problem in modern years due to its huge manufacture and applications. Water pollution and energy crisis are the main universal issues in the current days. Water pollution is a key issue round the world which is causing numerous harmful effects to human health and environmental systems. A report of U.N announces that normal about 1800 children lower the age of five years die universal from diarrhea owing to dirty water Azo dyes are the major group of dyes used in textile industries in present study. Synthesizes of Molybdates and their sulfonated graphene oxide nanocomposite and their characterization using different technique for example FTIR and SEM was carried out. Optimization of different experimental parameters such as pH, temperature, adsorbent dose, contact time and initial pollutant concentration was done to achieve the maximum adsorption capacity. Different equilibrium kinetics and thermodynamic model were applied to determine or checked the nature, rate and feasibility of adsorption process. Obtained results were analyzed statistically by applying mean, standard deviation and linear regression.

Keywords: Degradation, Molybdates, sulfonated graphene oxide, nanocomposite, dyes
COMPARATIVE EFFECT OF ORGANIC AND INORGANIC AMENDMENT ON REDISTRIBUTION OF ARSENIC FRACTION IN ARSENIC CONTAMINATED SOIL

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Arsenic (As) is a potential environmental pollutant and human are exposed to it all over the world. It causes an adverse health effect to human, such as hepatic, renal, neurological, immunologic and carcinogenic effect. The main aim of this study was to identify the arsenic toxicity in soil, comparative effects of the organic and inorganic amendment on redistribution of As fraction in As contaminated soil and also determine the outcome of incubation time. Two organic [poultry manure (PM) and farm manure (FM)], two inorganic amendments (zeolite and gypsum) including control, five treatments with four time interval T1 (0 day), T2 (14 days), T3 (28 days) and T4 (56 days) was applied to investigate the chemical speciation of As in sandy loam soil. Results indicated that after zero-day interval there was significance difference except zeolite among treatments regarding As exchangeable fraction. Fourteen-day incubation period showed significance difference between all the treatments. Arsenic concentration in F1 at second time interval for control, zeolite, gypsum, poultry manure and farm manure was 1.25, 0.96, 1.06, 1.19 and 1.22 mg kg$^{-1}$ respectively. Results after fifty-six days interval indicated that there was a gradual decrease in As concentration for F1. F2 concentration of As was 0.67 mg kg$^{-1}$ when soil was untreated with any amendment at zero time interval. When soil is treated with one percent (3 g in 300 g soil) inorganic amendments using zeolite and gypsum, As concentration was 0.38 and 0.45 mg kg$^{-1}$, respectively at zero time interval. It was revealed from result that As concentration became decreased with ageing but this decrease level was more in case of zeolite and gypsum. Data regarding F3 indicated that zeolite and gypsum has more significant impact on Fe-Mn oxide bound fraction as compared to poultry and farm manure. Results of F4 indicated that zeolite and gypsum has more significant impact on F4 fraction as compared to poultry and farm manures. Dissolved calcium increase As sorption but phosphate and carbonate reduce As sorption by competing arsenic sorption sites. It was revealed from result that a minute change was observed in all treatments in F5. It was revealed from data that time interval, concentration of As in exchangeable fraction was decreased in the order T1 > T2 > T3 > T4. In stance of treatment the As concentration was as control > farm manure > poultry manure > gypsum > zeolite.

Key Words: As concentration, Incubation, Organic, Inorganic Amendments, Fractionation, Soil.
RISK ASSESSMENT OF CONTAMINATION BY ANALYZING HYDROGEOCHEMISTRY OF WELLS SUPPLYING WATER TO RABWAH, DISTRICT CHINIOT, PAKISTAN

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Groundwater is the major source of drinking and agricultural water. Due to scarcity and low quality of groundwater, the need for water is fulfilled by a few wells. The current study was carried out on wells supplying water to part of Rabwah town. Samples from wells were collected and analyzed monthly for two the year 2016 – 2017 and 2017 - 2018. pH, Electrical conductivity (EC), Total dissolved solids (TDS), Total Alkalinity, Total Hardness, Calcium, Magnesium, Chloride and Sulfates were analyzed. An increasing trend was observed in pH, EC, Total dissolved solids, Total Alkalinity, Total Hardness, Calcium, Magnesium, Chloride and Sulfates. More seventy-two elements were analyzed by inductively coupled plasma–mass spectrometry (ICP-MS), Perkin Elmer ELAN. Seasonal variation was also compared. Increase in salts concentration was observed in each season of 2018 as compared in the same season of 2017. Although this increase in concentration was slight, this resulted in the degradation of the quality of water according to the WHO water quality guidelines. Continuous extraction of water lowers water to salt ratio. Solid liquid interface interaction increases salt concentration. This will be a big issue in the future. Assessment and monitoring of wells is necessary as over-extraction of water results in a decrease in the quality of groundwater.

Key words: Water quality, seasonal variation, Physiochemical analysis, Over extraction
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ENHANCEMENT OF ZINC IN WHEAT (*Triticum Aestivum* L.) AT DIFFERENT GROWTH STAGES THROUGH FOLIAR SPRAY OF ZINC LYSINE CHELATE

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An experiment was performed at Agronomic Research Area, University of Agriculture Faisalabad during 2017. The experiment was placed in RCBD under factorial arrangement by keeping 3 replications with net plot size of 4 m × 2.3 m. The aim of this study was to investigate the effectiveness of foliar Zn application at different growth stages on wheat. The data were collected on the parameters like number of total tillers, plant height, spike length, number of spikelets per spike, number of grains per spike, 1000 grain weight, biological yield, grain yield, harvest index, chlorophyll contents, zinc contents and protein contents in grain. The treatments comprise of Control, water spray, 0.5%, 1%, 1.5% Zn-lysine chelate and application time at Tillering, Booting and Tillering + Booting. The obtained results indicated that different concentrations of zinc-lysine chelate significantly increased wheat yield, but 1% zinc-lysine chelate at Tillering + Booting stage significantly increased yield of wheat (4912 kg ha⁻¹) as compared to other treatments.

**Keywords:** Wheat, zinc lysine chelate, plant height, biological yield, grain yield, harvest index.
VARIATION IN NEMATODE COMMUNITY COMPOSITION MODIFIED BY INDUSTRIALIZATION & URBANIZATION

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Soil contaminated with heavy metals (HM’s) imposes negative impacts on the biodiversity. As nematodes are sensitive towards HM’s in soil these can be used as a powerful bioindicators of soil pollution. The purpose of this study is to identify the behavior of nematodes feeding on bacteria and fungi affected due to disturbances in the soil and their use as soil quality indicator. Soil pH, concentration of metal, abundance and diversity of nematode was analyzed in different land use soils. Result indicated that Industrial and Urban soil showed highest concentration of Pb i.e. 31.23 mg kg⁻¹ and 29.12 mg kg⁻¹ respectively while that natural soil shows highest concentration of Cd i.e. 6.35 mg kg⁻¹. Both the abundance & diversity of soil free living nematodes were declined in the industrial soil with the elevated concentration of Cd (535 nematodes kg⁻¹ of soil) & Pb (535 nematodes kg⁻¹ of soil). This showed that nematodes are more sensitive to Cd & Pb in industrial soil. To confirm the results of a field data an experiment was performed in lab in control condition with different concentrations of metals. Nematodes were inoculated in soil with varying concentration of metals along with the control. Experimental results indicated that at higher concentration of metals, abundance of nematodes showed decline along with the decline in their diversity in all soil types. The experimental results of this study supported the results of field data, which indicated that with the increase in metals content numbers of nematodes in soil were decreased & can be used as indicator of pollution in soil.

Key words: Nematode, Bioindicator, Abundance, Diversity, Feeding Habitat
In the current study, the arsenite (As(III)) and arsenate (As(V)) removal efficiency of peanut shell biochar (PSB) was compared with peanut shell (PS) in aqueous solutions. Sorption experiments showed that PSB possessed relatively higher arsenic (As) removal than PS, with 95% As(III) (at pH 7.2) and 99% As(V) (at pH 6.2) with 0.6 g L$^{-1}$ sorbent dose, 5 mg L$^{-1}$ initial metalloid concentration and 2 h equilibrium time. Experimental data followed pseudo second-order model for sorption kinetics showing the dominance of chemical interactions (surface complexation) between As and surface functional groups. Langmuir model for sorption isotherm indicated that As was sorbed via monolayer sorption process. The X-Ray photoelectron spectroscopy (XPS) and fourier transform infrared (FTIR) spectroscopy analyses revealed that hydroxyl (–OH) and aromatic surface functional groups (C=O, C=C–C and –C–H) contributed significantly in the sorption of both As species from aqueous solutions through surface complexation and/or electrostatic reactions. We demonstrate that the pyrolysis of abandoned PS yields a novel, low-cost and efficient biochar which provides dual benefits of As-laced water treatment and a value-added sustainable strategy for solid waste disposal.

**Key Words:** Arsenic, biochar, sorption, peanut shell, XPS, speciation
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EVALUATION OF SACCHAROMYCES CEREOVIAE (YEAST) GROWTH RESPONSE TO ARSENIC STRESS

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The research was performed at Botany department, Nusrat Jahan College Rabwah Pakistan to determine growth responses of yeast on exposure to arsenic stress. Yeast strain was taken from NARC Pakistan. Few drops of different concentrations of sodium arsenide (1mg/L, 2mg/L, 3mg/L, 4mg/L, 5mg/L, 6mg/L, 7mg/L, 8mg/L, 9mg/L and 10mg/L) were applied to yeast grown on CLED media to determine zone of inhibition through disk, well and spread method. Stress applied yeast petri plates were incubated for 24 hours at 37°C. After incubation zones of inhibition were measured. Our study has shown that yeast is not resistant to arsenic stress, with increasing values of arsenic, yeast growth has declined. This reduction of yeast growth due to arsenic stress can pose severe problems for soil and over all plant growth. Hence strong competent measures are required to overcome arsenic issue.

Key Words: yeast, arsenic, CLED, well method, spread method, disk method.
SCREENING OF STRESS TOLERANCE LEVEL OF PSEUDOMONAS AGAINST ARSENIC STRESS

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The research was performed at Botany department, Nusrat Jahan College Rabwah Pakistan to screen stress tolerance level of pseudomonas taken from NARC PAKISTAN against different levels of sodium arsenide stress (1mg/L, 2mg/L, 3mg/L, 4mg/L, 5mg/L, 6mg/L, 7mg/L, 8mg/L, 9mg/L and 10mg/L) . Three drops were applied to pseudomonas grown on CLED media to determine zone of inhibition through disk, well and spread method. While control group was without sodium arsenide application. After application of various levels of arsenic stress, organism was incubated for 24 hours at 37°C. After incubation, zones of inhibition were measured. Our study has shown that pseudomonas cannot overcome higher levels of arsenic stress because in higher stress Petri plates, increased inhibitory zones were observed.

Key Words: pseudomonas, arsenic, CLED, well method, spread method, disk method
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EVALUATION OF DELETERIOUS IMPACTS OF ARSENIC OXIDE ON MORPHOLOGY AND BIOCHEMISTRY OF WATER LILY PLANT

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The experiment was performed at Botany department, Nusrat Jahan College Rabwah Pakistan to use water lily plant as bioremediation source against water dissolved arsenic oxide. Different concentrations of arsenic oxide (0mg/L, 100mg/L and 200mg/L) were dissolved in water. Arsenic dissolved water was placed in steel trays and lily plants were placed in arsenic contaminated water. On daily basis water was tested for arsenic levels using arsenic kit method. Up till four days lily plant was in good morphological order and dissolved arsenic concentration was decreasing because of absorption by lily plant. After one-week arsenic was very much less in water which showed that it was effectively absorbed by water lily but plants’ itself condition was adverse. Plant parts were subjected to various biochemical tests whose results reveled that arsenic oxide has disturbed plant growth. Hence it has been seen from this study that lily plant is nonresistant to arsenic stress.
Salinity is one of the major abiotic stresses to crop which spread over 80 million hectares of the world. Rice is the main food crop of estimated 40% of world’s population. The intend of this research was to evaluate the effect of organic and inorganic amendments in saline and saline soils on the leaching ability of N,P,K under rice crop and to determine the ground water contamination. These degraded soils could be ameliorated by adopting chemical, biological and physical measures of reclamation. These may be organic i.e. farm manure or inorganic i.e. sulfuric acid and gypsum which help to avoid the risk of salinity. Inorganic amendments and organic manures can contribute to increase the nitrate, potassium and phosphorus content of rice soils and hence help to improve the productivity. A lysimeters study was initiated to investigate the concentration of NPK in leachate from amended with organic (farm manure) and inorganic (gypsum and H$_2$SO$_4$) sources under rice crop. Phosphorus concentration in leachate amended by farm manure was more compared to other amendments and was 6.69 ppm. Moreover, phosphorus availability at pH 6.5-7.0 is high and at high pH becomes low. Nutrients leaching was more in sandy soil due to its less holding capacity except potassium, but potassium leaching was more in clay soil. Farm manure application was best in all the conditions except in P leaching. The E.C: SAR level affected the NPK leaching for all the amendments. At high E.C: SAR level more leaching appeared. Over all gypsum application was best for P and N but in case of K its results were not so appreciated as Ca$^{2+}$ has antagonistic effect with K$^+$. For P leaching the trend was as farm manure > sulfuric acid > gypsum > control, for K leaching was as gypsum > sulfuric acid > Farm manure > control and for N leaching was as sulfuric acid > gypsum > Farm manure > control. In case of leachate the trend was L1 > L2 > L3 > L4 for all the type of nutrients as well as for both clay loam and sandy loam soils.

**Keywords:** Salinity, Organic, inorganic amendments, Leaching, Rice
IMPROVEMENT OF SOIL FERTILITY AND CARBON SEQUESTRATION BY USING BIOCHAR

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Intensifying greenhouse gases, degraded land, alkaline soil, contaminated water, nutrient and moisture deficiency in lands reduces the water holding capacity have appeared as emergent issues for Pakistan’s economy. Higher pH, heavy metal pollution, deficiency of wastewater treatment techniques, lack of organic soil and lack of ion exchange capacity are major concerning issues. Bio-char achieved as a product from pyrolysis, ability to increase the water holding capability of soil and nutrient levels also with the byproduct of syngas. The word bio-char is used comparatively more in modern era because of its ability to recycle the waste. Addition of biochar into the soil increased about 20-30 % organic carbon. Bio-char in combinations with other amendments containing high nutrients level such as manures and solid waste can directly apply to plants for improvement of nutrients and growth. It is also known as a conditioner for the soils and enhance the carbon/nitrogen ratio in the field experiment. Though, only bio-char was not best option as a carbon source for the soil fertility as it decreased over time interval of one year about 47.39% to 36.54%. It is because of some plant biomass left in the biochar in incomplete process of pyrolysis in anaerobic condition and indicating very high ratio of hydrogen/carbon of 0.64%. The study recommended the use of Parathenium biochar at very small amount to the fields not only as additional carbon content but also as a nutrient to the microbes and used as eco-friendly and sustainable energy product. The stabilization of bio-char contribute to carbon sequestration as best management of organics catering climate change issues by: Methane gas recovery from landfills, adapting waste to energy techniques, improving carbon sequestration in soils, minimum use of industrial energy and reducing emissions, energy recovery in production of bio-char, and used as soil moisturizer in amendments.

Key words: Parathenium biochar, carbon sequestration, soil fertility, biogas
USE OF ZEOLITES AS A POTENTIAL TECHNIQUE TO IMMOBILIZE HEAVY METALS FROM THE SOIL

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Due to increased human activities such as industrialization, urbanization, use of fossil fuels as a result, environmental pollution has increased rapidly; the exhaust from automobiles is a rich source of emission of toxic pollutants in the environment and studies have shown the serious health effects of these pollutants on the human, animal, and plant health. Among these hazardous pollutants, heavy metals Pb, Fe, Cd, Mn, As, Cr are the most commonly known pollutants. The accumulation of heavy metals is likely more in soil than the other sources due to naturally geological processes such as soil erosion and anthropogenically like application of untreated industrial, commercial, household wastewater to soil, application of synthetic fertilizer and pesticides. Some of these metals are necessary for the plant growth, while the excessive availability of heavy metals directly leads to different disorder to plant health, ground water quality and human health ultimately. Severe bombardment of these heavy metals can lead to the anemia, brain damage and kidney malfunction. So, it’s now much important to study the availability and concentration of these metals in the soil and at the same time the remediation of these heavy metals is also very important because these heavy metals are non-biodegradable.

Consumption of energy is the basic constituent of daily life, due to rapid increase in the population the required quantity of energy has been tremendously increased. Alike other sources of energy coal counts to be the one of major source therefore there is a lot of coal mining in order to meet the required amount of coal, during the coal mining a lot of mechanical processes took place and cause the environmental pollution too at the same time the coal gangue is also left which is termed as waste it is formed by stacking and is very much toxic. China is one of the major countries for coal-based energy production, in China there are thousands of coal mining sites from these sites almost 100 million tons of coal gangue is produced per year. So, the recycling rate of this waste is very less then production. During the recent time, scientists are preferring the use of zeolites both natural and synthetic in order to minimize the availability of heavy metals and to some extent remove the pollutants also. Due to the exchange capacity of zeolite it can eliminate the contaminants while zeolite also have the catalytic property also that have the capability to adsorb the pollutants. Zeolite is the most efficient ion exchange and ion selective material for removing and stabilizing heavy metals and enhance soil fertility. So, zeolite synthesized from coal gangue can be used as environmentally technique for immobilization of heavy metals.
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SOIL CADMIUM CAN ALTERNATE PLANT RESISTANCE STATUS AGAINST BREVICORYNE BRASSICAE WHICH CAN BE MANAGED BY ANIMAL MANURE AND PHOSPHOROUS FERTILIZERS IN BRASSICA NAPUS

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In Pakistan and other countries facing deficiency of fresh water irrigation, it’s a common practice to grow crops under sewage water carrying Cadmium toxicities to much level. This can make a robust plant growth owing to containing organic waste constituencies but simultaneously can pose predicaments of heavy metal toxicities like cadmium (Cd) and low soil pH. Canola crop, which is facing Brevicoryne brassicae as major pest, was chosen for this study to ameliorate the impacts of pest cum toxicity bilaterally via soil amendments. These were applied in the form of animal manure and phosphorous fertilizers (i.e., DAP at recommended and half doses with individual phosphorous source). Additionally, soil constituencies were also varied by applying pH varying products to intensify situation by soil conditioners (for normal to low pH) along with sewage water application carrying 60 ppm Cd toxicities. Potted study was preferred to avoid any persistent field soil contamination. Pots were placed in screen house for semi-natural conditions, where B. brassicae winged forms can easily hovers over plants, excluding other major feeders like P. brassicae and T. ni etc. Plants showed better deterrence with no aphid infestations records in all other seven treatments, but plentiful B. brassicae infestation up to 15 cm apical top was noticed in low pH+60 ppm Cd toxicities followed by 2 cm in half recommended dose of DAP+60 Cd treatments. This concisely showed that sewage water can make the plants more B. brassicae susceptible but animal manures and phosphorous fertilizers can mitigate both stresses of insect and low pH cum Cd noxiousness simultaneously.

Key Words: Brassica napus, Soil ameliorations, Integrated use, Aphids, Soil toxicities
PLANTATION THROUGH INCENTIVE APPROACH TO TACKLE CLIMATE CHANGE EFFECTS IN PAKISTAN

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Pakistan is now more vulnerable to the effects of climate changes due to rapid decrease in its forest cover. A report of UN institution has reported that Pakistan forest cover stands at 2.66pc of the total land of the country. World Wildlife Fund (WWF) declared a statistical calculation which reveal that Pakistan has highest deforestation rate in Asia, in result Pakistan committed to increase 2 percent of its forest cover whereas 25 percent recommended. Rain patterns has changed in the country and facing water shortage due to rapid deforestation. A single tree can absorb an average of 50 pounds a year of atmospheric carbon dioxide and a mature tree upkeep 1.4 percent of population by generating oxygen back into atmosphere. With the reference of WWF watershed project, Trees contribute in recharging water up to 0.96 million liters of water per year per hectors, so there is need to take a revolutionary step to increase plantation rate across the country. In this study sustainable development goal 15 followed to conserve and restore forest. The aim of this study is to use incentive approach to manage forest to reduce climatic effects in the reference of economic and forest related indicators, moreover, examined implication about direct and indirect incentives. Result and discussion based on impact of incentives on plantation development and management and conclude with the framework compromising association of forest with climate improvement and need to increase the interest among private investors to participate and promote plantation rather than focus on goals and objective of government forest agencies.

Key Words: SDG 15, Pantation, Incentive Approach, Climate Change
Arsenic (As) is highly toxic heavy metal that is recognized as a hazard of water, mainly in groundwater. Direct drinking of As contaminated groundwater or indirectly consumption of As contaminated food has very toxic impacts on human health. About 110 million As affected population lives in the countries of South-east Asia such as China, India, Bangladesh, Nepal, Taiwan and Pakistan. Thus, remediation of As contaminated drinking water is very important by adopting effective ways to overcome this hazard of health. Therefore, many scientists are involved to examine the efficient, proper and low-cost treatments for the remediation of the As polluted water. Many conventional, methods for example electrodialysis, ion exchange and reverse osmosis are used commonly for the treatment of HM polluted soils, but these methods have higher costs and production of sludge. Thus, keeping in mind the above evidences, this study includes the health effects of As polluted drinking water and many other advanced and efficient method that is used for the treatment of As contaminated drinking water. Therefore, wasted peels, as lignocellulose biomass- higher organic contents, have promoted the new methods for the renewable and sustainable production of adsorbents for the applications of water treatment. Hence, this study addresses the usage of agricultural wastes (bagasse of sugarcane, wheat straws and peels of many seasonal fruits) as bio sorbents. This method posing the low cost and environmentally friendly solution for remediation of the As polluted water bodies. The results of this methods for example the pH, anions, cations, pH, organic matter and many other elements such as contact time, temperatures and dose of sorbent) on the bio sorption of As and efficient method for the dumping of used bio sorbents to overcome the further pollution of As in the environment are also discussed.

Key words: Bio sorption, Arsenic Contamination, Drinking water, Fruit peels
EVALUATION OF FOLIAR APPLICATION OF SILICON ON WHEAT GENOTYPES UNDER DROUGHT CONDITIONS

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Wheat is an important cereal crop in Pakistan. Silicon (Si) is a vital element for plants under stress and non-stress conditions that is involved in enhancing physiological, structural stability and metabolic activity in plants. Water stress significantly effects on growth and yield of wheat. To mitigate the negative effect of water stress on yield of wheat crop, an experiment was conducted. Research was comprised of two experiments. Factorial arrangement was used with, 1. Screening of wheat genotype at seedling stage 2. Screening of wheat genotype at mature stage, with (CRD). The field experiment was comprised of water stress conditions i.e. no water stress and water stress, wheat varieties and foliar application of silicon i.e. no spray and silicon spray @ 6mM. Water stress was imposed at tillering and booting stage. For field experiment Randomized Complete Block Design have three replications was used. Drought stress significantly reduced relative water content, chlorophyll content, leaf area, grain per spike, 1000-grain weight and grain yield of all wheat varieties. Silicon significantly increased all these parameters under stress and non-stress conditions. Silicon mitigates the negative effect of water stress and enhanced yield. Furthermore, foliar spray of silicon enhanced yield of all wheat genotypes but Chakwal-50 and Aas-2011 had significant results under drought conditions. The results suggest that foliar application of Si is very effective under drought conditions by maintain relative water content, water potential, osmotic potential and chlorophyll content.

Keywords: Foliar spray, Silicon, Drought, wheat varieties, yield.
Lack of knowledge about the plant nutrition and selection of a variety is one of the bottlenecks to sustain high wheat production in Pakistan. Therefore, a field experiment was conducted at Agriculture Research Farm, The University of Agriculture Peshawar to find out the nitrogen use potential of different hybrid lines and improved varieties of wheat during 2017-18. Atta-habib and pirsabak-2013 were the improved varieties while YZ-15 and MY-512 was the hybrid lines used in the experiment. Nitrogen levels used in the study was 0, 120, 160 and 200 kg N ha$^{-1}$. The results revealed that maximum plant height (97 cm) and harvest index (40%) was observed in MY-512, maximum spike length (10.6 cm), biological yield (9019 kg ha$^{-1}$), grain yield (3156.5 kg ha$^{-1}$) and grain nitrogen content (1.97%) was observed in pirsabak-2013 variety. Similarly, in different nitrogen applications, maximum plant height (94 cm), spike length (10.3 cm), biological yield (8647 kg ha$^{-1}$), grain yield (3381 kg ha$^{-1}$), harvest index (39%) and grain nitrogen content (2.20%) was noted with the application of 200 kg ha$^{-1}$ which was statistically at par with the application of 160 kg N ha$^{-1}$. The hybrid lines, improved varieties and nitrogen levels interactive effect was found non-significant. From the results it was concluded that pirsabak-2013 variety and application of N @ 160 kg ha$^{-1}$ exposed best results among other varieties and nitrogen levels and is recommended to be used for the enhancement of wheat production under the agro-climatic conditions of Peshawar.

**Key Words:** Hybrid lines; improved varieties; nitrogen levels; wheat productivity
INCREASING THE BIOCHAR ADDITION RATE INCREASES THE SOIL C SEQUESTRATION RATE AND REDUCES SOIL C MINERALIZATION

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Biochar, a material produced from organic residues by pyrolyzing them in oxygen-limited conditions, is being proposed as a soil conditioner to sequester atmospheric CO², improve soil C stocks and thereby to mitigate climate change and improve soil fertility. The research has mainly focused on temperate and tropical soils whereas the arid and semi-arid soils having calcareous composition have been little studied. Therefore, we designed a study where we added two biochars i.e. rice-derived biochar (RS-BC), and sugarcane-derived biochar (SC-BC) in a calcareous soil at two rates i.e. 1% and 5%. The BC amended and control soils were incubated for 73 days and soil respiration was measured over the whole duration. Soil microbial biomass (MBC), ammonium (NH₄⁺-N), nitrate (NO₃⁻-N) and available phosphorus (P) were determined after 37 day and 73 d of incubation. Colony forming units (CFUs) were determined at the end of the experiment. We found that both the biochars induced release of significantly higher cumulative CO₂-C than control at the end of the incubation (P < 0.05). According to the temporal dynamics of the cumulative CO₂-C emission cumulative CO₂-C release was higher in biochar amended soils at two rates of addition after 5d of incubation. However, this increase was significant only in the 1% SC-BC. After 37d and 73d of incubation, the cumulative CO₂-C release was significantly higher for both biochar amended soils at both rates with respect to control. However, the rates of biochar addition for a particular biochar did not differ with respect to cumulative CO₂-C release at these stages of the incubation. Moreover, both the biochars induced release of similar amounts of cumulative CO₂-C in the experiment. Contrary to previous findings, biochar addition did not increase P and NO₃⁻-N content after 36.5d and only increased P by the end of the incubation. Fungal CFUs were found higher in BC amended soils whereas bacterial CFUs remained unchanged indicating the better potential of the fungi to utilize added biochar.

Key Words: Rice-derived biochar (RS-BC), Sugarcane-derived biochar (SC-BC), Microbial biomass carbon (MBC), Colony forming units (CFUs), Ammonium (NH₄⁺-N), Nitrate (NO₃⁻-N)
AMELIORATION OF POLYETHYLENE GLYCOL SIMULATED WATER DEFICIT STRESS BY CARBONIC ANHYDRASE CONTAINING ENDOPHYTIC BACTERIA IN MAIZE SEEDLINGS

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Drought is a major limiting factor to plant growth that adversely affects the agricultural productivity worldwide and its incidence is predicted to increase under climate change. To secure the agriculture productivity under current and future climate changes, amelioration of drought stress is a major challenge. Endophytic bacteria are well known to induce drought tolerance and improve plant resistance against drought stress. In the present study, 150 endophytic bacteria were isolated from different parts of maize and screened for drought tolerance ability. Out of 150, 50 isolates exhibited highest tolerance were further screened for carbonic anhydrase activity. Among them, ten drought tolerant carbonic anhydrase containing endophytic bacterial isolates were tested for plant growth promotion under water deficit condition on maize crop. Results showed that drought stress significantly reduced plant growth, however, inoculation with drought tolerant carbonic anhydrase containing endophytic bacteria significantly improved the root length, shoot length, root dry weight and shoot dry weight. Moreover, endophytic bacterial isolates also improved the carbonic anhydrase activity and photosynthetic activity under normal as well as water deficit stressed conditions. Based on these results, it is concluded that drought tolerant carbonic anhydrase containing endophytic bacteria helps in plant growth promotion under drought stress.

Key Words: Drought, Endophytes, Plant growth promotion, Maize
MICRONUTRIENT STATUS OF FRUITS GROWN IN PUNJAB

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Citrus and Guava fruits are very nutritious, offering a host of vitamins, minerals and plant compounds that keep us healthy. Average yields of our orchards (9.5 tones ha⁻¹) are much less when compared with the world average yield of more than 25 tones ha⁻¹. Non judicious use of chemical fertilizer especially micronutrient are main causes of yield reduction in many orchards of Pakistan, especially Punjab. A lot of awareness has been created for the use of macronutrients alone, but a little work has been done to identify micronutrients deficiencies that limit fruit yield and quality. Micronutrient (Zn, Fe, Mn, Cu) are very important elements for plant growth, high yield and fruit quality. Their deficiency is reported in Punjab but how much deficiency of specific element occurs in specific area is not reported. To overcome the micronutrient deficiency in orchards, firstly need to assess current micronutrient status of fruits. So, keeping in view their importance; this study has been planned to assess the micronutrient status of citrus and guava orchards in Faisalabad and Sheikhupura districts. For this purpose, 480 samples were collected from different orchards of the Faisalabad and Sheikhupura districts. Fruit samples were analyzed for Fe, Zn, Cu and Mn. The results revealed that in citrus orchards the deficiency of Fe, Zn, Cu and Mn were noted, and it was found in 100% orchards for all micronutrients. In guava orchards, the situation is somewhat better where Fe, Zn, Cu and Mn deficiency occurred in 50, 93, 28 and 98% orchards, respectively. Based on these results, it is dire need of time to create awareness among the farmer community about the importance of micronutrient for orchards to increase fruit production and to improve the fruit quality.

Key Words: Micronutrient, citrus, guava, deficiency, survey.
HEAVY METAL CONTAMINATION OF GROUND WATER: A CASE STUDY

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Water scarcity is major issue for Pakistan’s agriculture and around the world which is expected to worsen dramatically during the 21st century. Over exploitation of groundwater, natural and anthropogenic contamination is becoming major problems now for humans. Groundwater quality of major cities in Pakistan is deteriorating because of unchecked disposal of industrial wastewater and non-judicious use of fertilizers, pesticides and insecticides. This study was planned to determine the quality of groundwater by quantifying its heavy metals content (Pb, Cd, Ni, Cr & As), its pH and EC from the district Faisalabad. Groundwater samples were collected from urban areas of Faisalabad district. Quantification of Pb, Cd, Ni, Cr and As was done by atomic absorption spectrophotometer using calibration curve. Result showed that pH and EC ranged 7.23 to 8.40, 0.47-5.39 dS m⁻¹, respectively. Heavy metal contents ranges are Pb (7.7-100.2 µg/L⁻¹), Cr (0.1-152 µg/L⁻¹), Cd (0.0-8.60 µg/L⁻¹), As (10-117 µg/L⁻¹) and Ni (0.0-228.8 µg/L⁻¹). The results indicated that heavy metal concentration in groundwater samples were Pb 56%, Cr 30%, Ni 39% and Cd 13% above than WHO standards. In future, this high range of heavy metals reported in samples of Faisalabad areas might be creating health problems to the humans either directly or indirectly via entering into the food chain.

Keywords: Heavy metal, Groundwater, Quality, Faisalabad, Health, WHO standards.
NITRATES IN GROUNDWATER: CAUSES OF NO$_3$ LEACHING AND THREATS OF WATER POLLUTION IN CENTRAL PUNJAB

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A range of chemicals including nitrate, can leach or pass through the soil profiles and potentially contaminate ground water. More ingestion in form of nitrates, nitrites and nitrosamine may cause large numbers of health hazards like methaemoglobinaemia and stomach cancer in nurslings. Though nitrates in the form of NO$_3$-N generally are not an adult public-health threat, however ingestion in drinking water by infants can cause low oxygen levels in the blood, a potentially fatal condition. Therefore, this study was conducted in the areas where high doses of nitrogen fertilizers are being applied to crops to assess NO$_3$-N concentrations in soils and tube-well waters. For this purpose soil samples were collected from 0-30, 30-60, 60-90 and 90-120 cm soil profile depths for estimation of NO$_3$-N content. Similarly, underground water samples (from water pumps, tube wells and hand pumps) from the same sites of villages were also collected from various installed depth and determined NO$_3$-N concentration in groundwater. The results of soil analysis showed that the NO$_3$-N concentrations were well below the WHO standards. For this purpose, 466 soil samples were collected from villages of Multan, Sahiwal and Khanewal districts. The results showed that NO$_3$-N leaching occurred, but it is only up to 60 cm soil depth. The highest average NO$_3$-N content (16.85 mg kg$^{-1}$) was found at 0-30 cm soil depth and the lowest (6.54 mg kg$^{-1}$) were found at 90-120 cm. The data also revealed that mean NO$_3$-N content at 0-30, 30-60, 60-90 and 90-120 cm depths were 16.85±4.05, 15.21±4.77, 9.94±3.36 and 6.54±2.62 mg kg$^{-1}$, respectively. The results regarding underground water samples (tube well) from the same sites from all the three districts showed that NO$_3$ were found in all the water samples but it were only in traces. Total 112 groundwater samples were collected from Multan, Sahiwal and Khanewal Districts from tube wells installed at farmer’s fields. The data showed that the highest NO$_3$ contents did not exceed than 12.45, 8.61 and 10.6 ppm in Multan, Sahiwal and Khanewal districts respectively. This study revealed that NO$_3$ content in underground water are well below the maximum admissible limit of WHO i.e. 50 mg L$^{-1}$.

**Key Words:** Nitrates, leaching, causes, pollution, central, Punjab, Pakistan.
Climate change has turned out to be one of the most important issues now because it is directly disturbing our standard of living, crop husbandry and farming systems. Pakistan’s economy is totally reliant on agriculture and its major industry or exports are based upon agricultural produce, so any detrimental impacts of climate change are absolutely decreasing its crop yields specially cotton, wheat, rice, maize, sugarcane and fruits. Some extremes weather events like hailstorms, high drought, winds, temperature, precipitation and heat waves not only damaged the crops but also responsible for other associated facts like plant diseases, lowered the nutritive quality, pests infestations, disorders in ozone and rise in CO$_2$ concentrations. Climate change resulted into decreased crop yields because mineral element nitrogen decreased with increasing CO$_2$ levels. It was determined that Fe and Zn concentrations in wheat, rice and maize grains were reduced with increase in temperature and drought. Crop water requirement is more in mid-season growth stage. Sometimes plant showed resistance against drought in a normal way by production of abscisic acid which ultimately act as a stress hormone which protect leaves from desiccation or water loss. By controlling of stomatal functions, plants survive under high temperature and drought conditions. During 2017 and 2018, the straw and grain yields of wheat was reduced owing to unexpected temperature rise in March and this ultimately decrease the overall wheat growth period by eight days. This decrease in days to maturity resulted in decreased grain yield up to 5 percent. High rainfall and hailstorm during Feb to March 2019, resulted into crop injuries and lodging of wheat, sunflower, vegetables, maize and fruit plants. During summer months, insect and pest attack increased in hot and humid conditions, therefore proper management of cotton, fruits and vegetables. It was also revealed that under severe drought and hot weather conditions, foliar spray of 1 % urea and 2 % KNO$_3$ substantially decreased the detrimental impacts of drought and increased the crop growth. Splitting of irrigation into more splits and mild irrigation up to 1 inch was also proved better significantly for cotton crop during hot months and for wheat crop during frosty nights of winter.

**Key Words:** Crop, nutrient, management, climate, change, scenarios, Pakistan.
NUTRITIONAL STATUS OF VEGETABLES RELATED TO MICRONUTRIENTS AND HEAVY METALS GROWN IN TUNNELS

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For normal metabolic functions in human body, different nutrients are required in significant amount. Vegetables are the rich source of nutrients, carbohydrates, vitamins and proteins. For getting high yield of vegetables to meet the population food requirements, we often compromise over the quality. Micronutrients are required for the normal body functioning of human being by consumption of vegetables micronutrient the requirements of the body fulfilled. Keeping in view the above stated facts, a survey project was conducted to monitor the actual status of heavy metals and micronutrients in vegetables samples grown in tunnels. According to the results substantial amount of heavy metals (Cd and Pb) found in all vegetable samples while (100%) samples of Spinach, Cabbage, Ivy-gourd, Ridge-gourd, Cucumber (86%), Bitter gourd (73%) samples were above safe limit for Cd. On the other hand Cucumber (100%), Bell pepper (83%), Tomato (75%) and white bitter gourd (83%) samples were above safe limits for lead. Micronutrients contents in all vegetables were low but the overall trend indicated that cadmium (Cd) and Lead (Pb) concentration was too high in all vegetables samples

Key Words: Micronutrient, Tunnels, Heavy Metal, Vegetable
COMPARATIVE STUDY OF SOIL AND FOLIAR FERTILIZATION OF NITROGEN AND POTASSIUM ON MAIZE GROWTH UNDER HIGH pH SANDY CLAY LOAM SOIL

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This study was conducted at soil chemistry section during 2017-18 and the objective of this study was to evaluate the effectiveness of soil and foliar fertilization of nitrogen and potassium on maize growth under high pH sandy clay loam soils. The recommended dose of N, P, K used were 275-125-75 kg/ha. Treatments used were: T1: Control: Recommended dose (RD NPK), T2: [N (½ at sowing + 2 % spray at 30 and 45 days after sowing (DAS)] + RD of K, T3: N + K (½ K at sowing + ½ at 30 DAS), T4: N + K (⅔ K at sowing + 2 % spray at 30 and 45 DAS), T5: N (⅔ at sowing + 2 % spray at 30 and 45 DAS) + K (½ K at sowing + ½ at 30 DAS), T6: N (⅔ at sowing + 2% spray at 30 and 45 DAS) + K (⅔ at sowing + 2 % spray at 30 and 45 DAS). Phosphorus was applied in all treatments as recommended dose at sowing. The soil analysis showed that soil is poor in fertility (P=6.7 ppm, K=151 ppm), low in OM (0.78 %), sandy clay loam in texture, high in pH (8) but without any salinity and sodicity hazards. Yield data parameters indicated that maximum maize grain yield (7.29 t/ha) was recorded in T6 where N and K was applied as soil and foliar application. While minimum yield (5.39 t/ha) was obtained from treatment T1 (control). Plant analysis showed that maximum P (0.22%) and K (0.38%) concentration in grain were recorded in T6 and it was better than other treatments. Maximum biomass (37 t/ha) was obtained from treatment T6 while lowest was (33 t/ha) from T2. The statistical analysis about biomass showed that all treatments were at par with each other. This comparative study concluded that the soil and foliar fertilization of N and K at sowing along with 2% foliar application after 30 & 45 days after sowing found best for getting best maize grain yield at high pH sandy clay loam soils.

Key Words: Foliar fertilization, Nitrogen, Potassium, Maize
CROP RESIDUE MANAGEMENT TECHNIQUES FOR FOOD SECURITY IN CHANGING CLIMATE SCENARIOS

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Food security and Climate change are twin challenges which need to be addressed simultaneously. Climate change has significant effect on agriculture and food security, triggering new risks contests and increasing existing vulnerabilities. Agriculture sector is more vulnerable to climate change. Burning of crop residues is a severe threat to the climate by the emission of greenhouse. While Carbon sequestration is a main implement to counter the effect of climate change in diminishing water scenarios. A five years study was conducted, to find out the impacts of various crop residues management techniques on the yield of rice in alkaline calcarceous soils. The rice crop was grown as Farmer’s Practice, Burnt Practice and Rotavation Practice with four fertilizer treatments in each block. The results depicted that incorporation of crop residues into the soil had considerable impact on paddy yield (5.2 t ha⁻¹) over burnt (4.6 t ha⁻¹) and traditional (4.6 t ha⁻¹) practice. On the other hand, there was significant increase in the organic matter contents of soil from 0.69% to 1.02% after five years. Whereas the lowest OM contents (0.47%) were observed in the plot where crop residues were burnt without addition of fertilizer. The result showed that there was a substantial increase in soil OM contents by the incorporation of crop residues regularly, which ultimately increased the grain yield of rice. From the study, it was concluded that Incorporation of crop residues in soil helps to counter the climate change, improve soil health for sustainable food production.

Key Words: food security, burning, climate change
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OZONE GENERATOR AN EFFICIENT WATER MICROBIOLOGICAL CONTAMINATION REMEDIAL APPARATUS

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Abdus Salam School of Sciences

Contaminated water is a health hazard for most of the third world countries. One of the reasons of this contamination is the improper sewerage system which causes cross-contamination due to leakage of sewerage pipes. Various techniques have been used to remove water bacterial contamination. Ozone has been proved of disinfecting bacteriological contamination. In the current study, we designed a low-cost and efficient ozone generator which decreases the microbiological contamination in the water. Its efficiency was analyzed by Relative luminous unit (RLU), Oxidation reduction potential (ORP) and by observing bacteriological colonies on growth media. Results indicated that there is an increase in ORP value and decrease in RLU values when ozone was passed for 15 minutes. No hazardous change in pH was observed. Its effectiveness starts within 5 minutes and continued until 15 minutes. The intensity of bacterial growth on media confirmed our observations. It possesses strong oxidizing power and requires short reaction time, which enables the germs, including viruses, to be killed within a few seconds, produces no taste or odor, provides oxygen to the water after disinfecting, requires no chemicals, removes color, taste and odor and avoiding any undesirable residual effects.

**Key Words:** ORP, RLU, Bacterial irradiation, microbiological contamination
EXPLORING THE CHROMIUM (VI) CONTAMINATION IN TANNERY WASTEWATER FROM DISTRICT KASUR, PUNJAB, PAKISTAN

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Contamination of aquatic environments by the addition of industrial effluents is a global environmental and health concern. A great risk is posed to our natural water resources from a widespread leather tanning industry, owing to its heavy use of chromium (Cr) salts in the tanning process. Two major forms of Cr i.e. hexavalent Cr (Cr(VI)) and trivalent Cr (Cr(III)), are predominantly found in tanning industry wastewater. Cr (VI) is the most toxic form of Cr which does not have any essential metabolic functions in the living organisms. The objective of this study was to determine the total Cr and its species in tanning industry wastewater samples collected from several tanning industries in district Kasur of Punjab, Pakistan. All the tanning industry wastewater samples (n = 86) showed elevated total Cr concentrations (range: 1-185 mg L\(^{-1}\); mean: 16 mg L\(^{-1}\); SD: ± 34 mg L\(^{-1}\)). The concentration of Cr(VI) and Cr(III) ranged from 1.5 to 17 mg L\(^{-1}\) and 10 to 174 mg L\(^{-1}\), respectively. The Cr(VI) concentration in most of the wastewater samples exceeded the National Environmental Quality Standard (NEQS; 0.25 mg L\(^{-1}\)) and the United States Environmental Protection Agency (US EPA; 0.1 mg L\(^{-1}\)) safe limits in wastewater. The chemical parameters of the tanning industry wastewater including pH, EC, cations and anions were found to be higher than their safe limits for wastewater. Our data showed that the tanning industry wastewater is a potential threat to the soil, surface and subsurface water and hence some suitable remediation strategies are needed to treat Cr-contaminated wastewater, such as employing a constructed wetland technology.

Key Words: Chromium, speciation, tanning industry, wastewater
REMOVAL OF HEAVY METALS FROM AQUEOUS SOLUTION BY USING ORGANIC ACIDS AND METAL OXIDES

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Heavy metals constitute some of the most dangerous pollutants of water, as they are toxic to humans, animals, and aquatic organisms. These metals are considered to be of major public health concern and, therefore, need to be removed. Nowadays nanomaterials have been widely used to remove heavy metals from wastewater due to their large surface area and high reactivity. Humic acid (HA) and fulvic acid (FA) exist universally in aquatic environments and have a variety of functional groups which allow them to complex with metal ions and interact with nanomaterials. Nanosized metal oxides (NMOs), including nanosized ferric oxides, manganese oxides, aluminum oxides, titanium oxides, magnesium oxides and cerium oxides, provide high surface area and specific affinity for heavy metal adsorption from aqueous systems. To date, it has become a hot topic to develop new technologies to synthesize NMOs, to evaluate their removal of heavy metals under varying experimental conditions, to reveal the underlying mechanism responsible for metal removal based on modern analytical techniques. Experiment conducted under complete randomized condition (CRD), to evaluate the effect of organic acid and metal oxide to remove heavy metals from aqueous solution. Result revealed this treatment showed highly significance results and improve aqueous solution quality and improve the quality of water for irrigation purpose in the field of agriculture. Thus result showed that organic acid and metal oxide should be better for the remediation of heavy metals.

Keywords: Heavy metals; humic acid; fulvic acid; nanosize metal oxides and adsorption
IMPROVEMENT IN MAIZE GROWTH BY INOCULATION OF DIFFERENT RHIZOBIUM SPECIES

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Maize (Zea mays L.) is the third most important high yielding cereal crop after wheat and rice in Pakistan. Potential yield of maize is less than in Pakistan than due to poor growth. By keeping in view, the role of endophytes to improve the plant growth, the study was planned with objective of effect of multi-strain bacterial inoculation on growth and yield of maize under complete randomized design (CRD), six treatments with three replicates in the glass house. As rhizobium act as P solubilizer, modulators and N fixers so providing nutrients essential for better growth. As microorganism are considered as indicators of soil health, microbial inoculation can be carried out to introduce the relevant bacterial growth. Plant growth-promoting rhizobacteria (PGPR) also hinder the effects of water deficit stress. Some bacteria have ability to increase growth and yield of various crops by enhancing root elongation, seedling vigor and physiological and biochemical responses of different crops. A pot study was conducted in the wire house of the Soil bacteriology section at Ayub Agriculture Research Institute (AARI), Faisalabad, to evaluate the comparative effect of sole strain endophytic bacteria to improve growth and yield of maize. For this purpose, we have used 5 different already purified rhizobium species of Guar, Brseem, Lentil, Jantar and Soybean. Results demonstrated that, all the treatments have significant effect on the growth of maize as compared to control. But treatment T₅ (rhizobium Sp. of Jantar) and treatment T₃ (rhizobium Sp. of Soybean) have highly significant result as compared to all other treatment. Conclusion was found that T₅ and T₃ to be better for the growth and yield of maize.

Key words: Rhizobium; P solubilizer; N fixers; Maize growth and indicators of soil health.
EFFICACY OF RHIZOBIUM IN INTERACTION OF ZEOLITE AND PRESS MUD TO ENHANCE THE GROWTH, YIELD AND NODULATION OF *Vigna Radiate* L.

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Pulses are the best and cheaper source of proteins to feed the rapidly growing world especially in developing countries. Mung bean contains about 24% proteins, so it would be the better source to meet their requirements. For this purpose, plant nutrition of mung bean is necessary to produce sufficient and healthy food for world’s expanding population. *Rhizobium* can increase the yield and productivity of crop plants especially the green legumes. Press mud (an organic amendment) is a potential source of many major nutrients and minerals required for sustainable plant growth. Pakistani soils are mostly deficient in major plant nutrients, so proper nutrient management is required for sustainable agricultural productivity. A pot experiment was conducted in completely randomized statistical design (CRD) to evaluate either *Rhizobium* along with press mud and zeolite could increase the yield of mung bean or not. There were 14 treatments along with 3 replications in which the given amendments were applied in different combinations. Suitable agronomic and plant protection measures were carried out. Pre and post research analysis were carried out using most compatible methods. All the collected data was statistically analyzed for Analysis of Variance (ANOVA) using suitable statistical software. Maximum increase in plant height at maturity, total number of pods number of grains per pod and number of nodules were also recorded maximum where 10 g zeolite, 50 g press mud along with rhizobium inoculations was applied. Zeolite used as an ideal trap for positive ions like ammonium, potassium and calcium.

**Key Words:** Legume; Press Mud; Zeolite; Rhizobium
INFLUENCE OF BANANA COMPOST AND DIFFERENT INORGANIC PHOSPHORUS SOURCES ON PHOSPHORUS AVAILABILITY AND GROWTH OF SUNFLOWER

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Phosphorous (P) is a 2nd most essential nutrient after nitrogen (N). It is a major growth limiting nutrient. Mostly, P is provided to the deficient soils through the use of synthetic fertilizers. Sometimes P availability to plants becomes limited due to its strong adsorption on organic matter and soil particles. P availability can be improved by improving different properties of soil through organic manuring along with the use of synthetic fertilizers. In this study, a pot experiment was steered to evaluate the impact of different P sources and banana compost (B.C) on P availability and growth of sunflower (Helianthus annuus L.). For this purpose, 1% B.C and different P sources (i.e. DAP, SSP & Rock phosphate) was applied to the selected pots. At the sowing time, in addition to different types of P fertilizers, recommended doses of potassium and N were applied. Crop was harvested after 60 days and different plant parameters such as seed germination, shoot and root length, dry and fresh biomass of shoot and root, other parameters were recorded and analyzed. Results showed that B.C and different P fertilizers affected the growth positively. For example B.C and DAP increased the plant height (12.5%), stem diameter (20.1%), head diameter (30.8%), No. of achene per head (12.8%), 1000-achene weight (11.1%) and achene yield (19.7%) as compared to control. Sunflower hybrid Hysun-131 produced more yield and yield related parameters where B.C and DAP was applied.

Key Words: Phosphorus; Banana compost; DAP; Synthetic fertilizers
CLIMATE CHANGE IMPLICATIONS TO 2030 AGENDA SDGs

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All the living creatures must fulfill their nutritional and residential necessities from earth’s available sources. The human population is wise of all creatures. They can better adopt and adjust with their surrounding environments. Utilizing its far and near resources equally. So, it is also their responsibility to save and secure the climate to be beneficial to all living creatures. From last few decades Climate change studies are focused. Earlier these involve recognizing is it happening. Now it becomes obvious to exist. So, the scientific attempts are working to adapt and mitigate these changes. The risk assessment authorities and governments must play their role to minimize the vulnerability. As more and more exertions to settle climate changes are in progress. The new SDGs (or Global Goals) are targeted to eliminate the root causes of hunger, poverty, inequality, conflicts, and Human development. SDGs are now promoting “one policy for all” nations rather compromising on just local agendas. Agenda 2030 is a transmission of global society towards more sustainable path. It not only working and planning strategy for developed nations but also for developing nations like Pakistan. It targets to eliminate constrains in the public development. It boosts the standard of living for everyone on the planet earth. It involves Ecological and environmental uplift along with descent employment and secured prospects. It is working in partnership of local, national and international bodies in all fields of human development. Like: Agriculture, food, education, and employment security; trade and transport technologies etc. It encourages the cooperation in achieving mutual goal beneficial to the present and future generations not just to governments. So, it is a good initiative to change the plight of poor nations and raising the status of moderating nations like Pakistan.

Key Words: Climate Change, Climate Change implications, SDGs, Agenda 2030.
BIOREMEDIATION: A GREEN SOLUTION TO AVOID ENVIRONMENTAL POLLUTION

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Bioremediation is a technique which involves different organisms and different substances to treat or detoxify the pollutants in eco-friendly way. It involves plants, microbes, fugus and different nutrient and gasses. It can detoxify a wide array of organic and in-organic pollutants like heavy metals and different types of pesticides and herbicides. Use of microbes for this purpose is the most common practice as these can be used anywhere i.e. in-situ and ex-situ, act as ecofriendly and produce no harm to the environment. Heavy metals and different types of pesticides are inevitable in nature. Regardless of their harmful effects, their use is increasing. there are many techniques to cope with their harmful effects but there is another issue that there are side effects of these techniques. Bioremediation is a sustainable technique to get rid of the pollutants from the contaminated sites as it leaves detoxified products on the sites. In this regard, we should study about the pollutant sources, effects, their remediation through a sustainable way with mechanisms and some of its advantages along with the draw backs with future needs of research.

Keywords: Heavy metals, Sources, Contamination, Toxicity, Remediation.
VEHICULAR NOISE POLLUTION: ITS ENVIRONMENTAL IMPLICATIONS AND STRATEGIC CONTROL

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Noise is unwanted sound, which is categorized amongst the most common environmental problem and have health hazard impact. This term is coined from the Latin word “nausea” meaning unwanted sound or sound that is loud, unpleasant or unexpected. Noise pollution has been recognized as one of the major hazards that impact the quality of life all around the world. Because of the rapid increase in technology, industrialization, urbanization and other communication and transport systems, noise pollution has reached to a disturbing level over the years which needs to be studied and controlled to avoid different health effects like high blood pressure, sleeplessness, nausea, heart attack, depression, dizziness, headache, and induced hearing loss. To address this situation, different countries has different strategies like vehicular noise limits and their regulation, vehicles physical health checkup, different time of operations for noisy traffic like trucks in the evening or night time, and noise pollution fines for noisy vehicles. Among the noise controlling methods, vibration control, machinery sealing, and use of rubber in machinery for noise control exists. There are noise mufflers and ear plug for use in noisy industries like glass industry, shelter belts and hedging plants in residential and urban areas.

Key Words: Traffic Horns, Annoyance, Community effects, Human health.
CARBON SEQUESTRATION AND ENVIRONMENTAL GREENING OF DEGRADED AGRO-ECOSYSTEMS

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Carbon dioxide (CO₂) is the most commonly produced greenhouse gas. It is produced from use of fossil fuels for energy production in industries, power plants and vehicles. CO₂ induced climate change effects on agriculture from loss of productivity, microbial diversity, organic matter in soil, drought, shifting of agro-ecological zones, loss in crop yield to even disasters like food security problems; other effects on environment includes extreme weather events like floods, intensive rains and storms, forest fires, sea level rise, loss of biodiversity and habitat loss. Due to the harmful effects of CO₂, different strategies are being used and developed to store it in its sinks rather than to allow its entry to atmosphere and face global warming and climate change. These methods include carbon sequestration, afforestation/reforestation, carbon farming, biofuel production, biochar production, ocean fertilization, rock solutions to capture CO₂, direct capture from air and the latest method of using cerium metal nanoparticles to capture CO₂. Carbon sequestration one method of reducing the amount of CO₂ in the atmosphere and storing it in soil and plants with the goal of reducing global climate change. To sequester CO₂, degraded soils can also be used by using well established reclamation techniques. By using degraded soils for this purpose has many benefits like more area could be under the crop cultivation, more food production by using these soil means less food security problems, economic benefits to farmers, more CO₂ will be sequestered in soils enhancing the soil and crop productivity which is a win-win strategy.

*Key Words: Sequestration, climate change, ecosystem*
POTENTIAL OF DIFFERENT RICE GENOTYPES TO REDUCE ARSENIC UPTAKE UNDER PADDY SOIL CONDITIONS

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Arsenic (As) toxicity has been found globally over 115 countries especially in South and Southeast Asia region. Rice is being used globally by three billion people for their energy requirement and is consumed is a staple food for the developing countries, including Pakistan, Bangladesh and India. Rice is cultivated under paddy soil conditions which favors reduced environment. Arsenic becomes mobile and bioavailable under paddy (reduced) soil conditions. The objective of this study was to screen eighteen different rice genotypes to evaluate their As accumulation and/or tolerate under paddy soil conditions in a pot experiment. Seedbed was prepared for nursery and after 30 days’ nursery were transplanted in pots in wire house of Institute of Soil and Environmental Sciences (ISES) University of Agriculture Faisalabad (UAF). Different rice genotypes (n=18) was grown in pots having As-contaminated soil (25 mg/kg soil). Arsenic has significant effect on plant physiological parameters (number of tillers, plant height, root and shoot dry weight, number of spikelets, dry weight of grains). Results showed that shaheen basmati has maximum number of tiller (8) while Bas-370 has minimum (3). Noor Basmati has maximum plant height (46.7 cm) and kainat basmati has minimum (27.3 cm). Basmati-2000 has maximum dry weight (2.5 g) of shoot, while kainat basmati show minimum (0.12 g). IR-6 show maximum number of spikelet (10) and Bas-198 show minimum (3). Bas-2000 show maximum dry weight of grain (9 g) and Bas-198 have minimum (4 g). Hydride generation-atomic absorption spectrometer (HG-AAS) was used to analyze As concentration in root, shoot and grain. Uptake of As in fine genotypes, root and shoot is (44 mg kg⁻¹, 22 mg kg⁻¹) more while in coarse is less (3 mg kg⁻¹, 2 mg kg⁻¹) respectively. Overall coarse genotypes perform better than fine genotypes and As stress has minimum effect on coarse genotypes. Data was evaluated by using appropriate statistical tools.

**Key Words:** Arsenic contamination. rice genotypes. Health risk assessment.
CRITICAL ANALYSIS OF CHROMIUM REMEDIATION TECHNIQUES FOR TANNERY WASTEWATER

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Chromium (Cr) is the most common carcinogen due to its use in industrial applications especially in tannery industry. Chromium contamination poses health risk for the human beings causing many disorders, including cancers and pulmonary diseases. In tannery wastewater, it is generally present in two forms, trivalent Cr (Cr(III)) and hexavalent Cr (Cr(VI)). Bioavailability and toxicity of Cr(VI) is more than Cr(III). Anthropogenic sources are enriching Cr(VI) concentration in the water system above the regulatory level (1µg L⁻¹). Various chemical, biological and integrated approaches for Cr(VI) removal and reduction have been reported. Widely used remediation approaches are adsorption, chemical reduction and membrane filtration. Adsorption is the most common technique for the removal of Cr(VI) in which different types of adsorbents (organic, inorganic or nanoparticles) are used. Strategies involving reduction of Cr(VI) lowers the activity of Cr(VI) by decreasing its concentration and converts it into Cr(III). These include chemical reduction, biological reduction and some advanced techniques like electrocoagulation. Limitations of both adsorption and reduction are requirement of chemicals, difficulty in reuse of extracted heavy metals, sludge production and high costs in some cases. Use of membranes is more efficient technique compared to others because of its low cost, improved separation efficiency and wide applicability even in low solute concentrations. Typically, bulk liquid membranes have been used for chromium extraction, but recently nanofiltration has been reported as a potential candidate to remove and recover heavy metals as well as multivalent ions from wastewater. But still most of the studies are limited to laboratory as it is a challenging technique. This review brings up limitations of extensively used techniques for Cr(VI) remediation.

Key words: Chromium remediation, Cr(VI), Wastewater, Adsorption, Reduction, Membrane filtration
Arsenic (As) is a potentially toxic and carcinogenic metalloid. High As-contamination of groundwater scattered areas is the current status of Pakistan. A number of assessments exist for the As-contamination of the drinking water in Vehari. However, there is scarcity of data about As contents in drinking water of health facilities/health care centers in Vehari. The current study, therefore, was carried out to assess As concentration and associated health risk in the drinking water of three health facilities (DHQ, RHC and BHU) of Vehari. In total, 75 drinking water samples were collected, and examined for As contents in addition to physicochemical characteristics such as, electrical conductivity, pH, total soluble salts, chloride, carbonates, bicarbonates, fluoride, nitrate, nitrite, calcium, magnesium and iron. Results indicated that the groundwater samples are not fully fit for drinking purposes with several parameters, especially the alarming levels of As. It was found that 52% drinking water samples have As concentration greater than WHO permissible limit (10 µg/L) and 17% having As concentration greater than Pak-EPA permissible limit (50 µg/L). The risk assessment parameters (ADD, HQ and CR) showed possible carcinogenic and non-carcinogenic risks associated with ingestion of As contaminated drinking water in the health care facilities. Based on the results of the present study, it is anticipated that hospitals and health centers in Vehari are in need of safe drinking water. The implementation of national/international standards for drinking water in health care facilities is a necessary measure to improve the services and increase local access to safe drinking water.

Key Words: Risk assessment, Drinking water, Arsenic, Health facilities, Vehari
COORDINATED EFFECTS OF LEAD AND CADMIUM ON GROWTH AND OXIDATIVE STATUS OF DIFFERENT MAIZE CULTIVARS

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Maize crop is highly susceptible to heavy metals toxicity particularly during the early growth stages. An experiment was carried out to unravel the coordinated effects of Pb (30mg/kg soil) and Cd stress (20mg/kg soil) on morpho-physiological growth, and oxidative metabolism in four maize cultivars (FH-949, FH-1231, DK-6142 and Malka-2016). Results indicate that Pb and Cd stresses severely reduced root and shoot growth (length and biomass) of all the maize cultivars. However, such reductions were more severe under combined application of Pb and Cd stresses. Combined application of these stresses resulted in a further increase in cellular damage, correlating with an induction in the levels of reactive oxygen species and regulation of antioxidant enzymes (SOD, CAT and APX). Among maize cultivars, DK-6142 and Malka-2016 showed the less reduction in morphological growth, which was associated with better antioxidant activities and maintenance of photosynthetic pigments as compared with FH-949 and FH-1231 cultivar.

Key Words: cadmium, lead, maize, morpho-physiological growth, oxidative metabolism
ASSESSMENT OF TOXICITY POTENTIAL OF SULFAMETHOXAZOLE (SMX) IN GRASS CARP USING MULTI-BIOMARKER APPROACH

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Rapid growth in human population, urbanization and industrialization has caused a proportional increase in the environmental contamination with several inorganic and organic pollutants. Among these pollutants, pharmaceuticals are considered as emerging contaminants due to their frequent use and detection in different environmental matrices in high concentrations. Sulfonamides have been widely used because of their low cost, effectiveness in tackling some bacterial infections, and their ability to improve animal performance. Due to their low volatility reach the aquatic environment and effect non-target species i.e. fish. Characterization of the potential ecotoxicological effects of Sulfamethoxazole (SMX) is much needed; to attain this objective, the present study assessed the potential toxicity of Sulfamethoxazole in fish by using different biomarker i.e. observation of histological changes in gills and liver of fish, change in antioxidant defense (Reactive oxygen species ROS generation in fish tissues) respiratory burst activity, bioaccumulation of SMX in fish tissues as well as change in biochemical parameters of fish. Acute toxicity of SMX in fish was find out by exposure to different concentrations ranging from 200-1200mg/l. Mortality was checked after every 24 hrs. Lethal dose (LD₅₀) finds out at <700 mg/l after 72 hrs. After that sub-acute toxicity was find out by exposing fish to different concentrations of SMX. The findings suggest that existence of a cause-and-effect relationship between the exposure to sulfamethoxazole and Enzymatic Activity (Respiratory Burst Activity), change in biochemical parameters, and excess generation of ROS indicate that antibiotic can exert oxidative stress and cause toxicity in fish tissues.

Key Words: Ecotoxicology, Oxidative Stress, Respiratory Burst Activity, Biochemical
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A NEW BIOCHAR FROM COTTON STALKS FOR As (V) REMOVAL FROM AQUEOUS SOLUTIONS: ITS IMPROVEMENT WITH H₃PO₄ AND KOH

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The present study is the first attempt to evaluate the potential of acid and base activated biochar derived from cotton stalks (CSB) for the removal of As from contaminated water. The CSB was treated with 0.5 M KOH (BCSB) and H₃PO₄ (ACSB) separately to change its surface properties. The CSB, ACSB and BSCB were characterized using BET, FTIR, and SEM analysis to check the effectiveness and insight of the main mechanisms involved in the removal of As. A series of batch experiments was performed using As contaminated synthetic water and groundwater samples. The effects of initial concentration of As, contact time, dose of the biochars, solution pH, type of the biochar and coexisting ions on the removal of As were investigated. Results revealed that BCSB efficiently removed As (90-99.5%) from contaminated water as compared with ACSB (84-98%) and CSB (81-98%) due to improved surface properties when As concentration was varied from 0.1-4.0 mg/L. The experimental data were best fitted with Freundlich adsorption isotherm as compared with Langmuir, Temkin and Dubinin-Radushkevich models. However, kinetic data were well explained with pseudo second order kinetic model rather than pseudo first order, intra-particle diffusion and Elovich models. The sorption energy indicated that physical adsorption was involved in the removal of As. The comparison of adsorption results with other biochars and their modified forms suggests that activation of CSB with base can be used effectively (4.48 mg/g) as a low cost and environment friendly adsorbent for maximum removal of As from contaminated aqueous systems.

Key Words: Cotton stalks; activated biochar; Arsenic adsorption; modelling; kinetics
INTERACTIVE EFFECT OF WATERLOGGING AND ARSENIC STRESSES ON MORPHO-PHYSIOLOGICAL GROWTH AND ARSENIC ACCUMULATION IN WHEAT

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Waterlogging and arsenic stresses are the two major factors affecting the crop growth and production worldwide, often occur together. While the individual effects of these stresses are studied in detail, the combined effects of these stresses are less understood. In this study, morpho-physiological growth and arsenic accumulation in wheat crop under the individual and combined waterlogging and arsenic stresses were studied. Different arsenic toxicity levels were 100, 200 and 300 mg kg⁻¹ soil. For imposing water logging stress, soil was kept saturated after 10 days of emergence. Waterlogging and arsenic stress significantly decreased plant biomass, chlorophyll content and relative water content in wheat, while the accumulation of reactive oxygen species and activities of antioxidant enzymes (SOD, POD, CAT, and APX) were increased. The adverse effects of the combined stresses were severe than the individual application of these stresses. The concentrations of arsenic in root and shoot were progressively increased with increasing the arsenic level particularly under waterlogged conditions. In short, co-occurrence of waterlogging and arsenic stresses caused more toxic effects on morphophysiological growth and enhanced arsenic accumulation in wheat as compared with the individual application of these stress.

Key Words: antioxidative defense system, arsenic toxicity, morpho-physiological growth, waterlogging, wheat
CHARACTERIZATION AND RECYCLING OF ORGANIC WASTE AS SUSTAINABLE FERTILIZER FOR SOIL AMMENDMENT

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The characterization and recycling of organic waste for the application of fertilizer, is important for sustainable nutrient management. The present study aims to present information regarding bioavailability of nutrients to maize crop from soils amended with different waste materials using the Hadley sequential fractionation method. Waste materials from four different sources, including animal waste fresh (AWF), animal waste compost (AWC), mixed waste fresh (MWF), and mixed waste compost (MWC) were selected to determine the different fractions of total, extractable and water soluble heavy metals (Fe, Zn, Ni, Mn, and Hg), phosphorus and nutritious elements (K, Ca, and Mg). The phosphorus was stepwise fractionated into water soluble extracted P (H2O-P), plant available (NaHCO3-P), Al associates (NaOH-P), Ca associated (HCl-P) residual forms. The overall P fractions extracted varied in order of HCl > NaOH > NaHCO3 > H2O while the nutrients concentration varied as Mg > K > Ca. The highest P content was found in AWF whereas minimum was observed in MWF. Analytical results indicated that composting of animal manures enhanced P availability and improved plant nutrition. The use of composted animal manures as soil amendment could be economically productive and would potentially ameliorate the major concerns associated with organic waste.

Key Words: Animal Manure, Mixed Waste, Phosphorus, Soil, Sustainability
COORDINATED EFFECTS OF LEAD AND CADMIUM ON GROWTH AND OXIDATIVE STATUS OF DIFFERENT MAIZE CULTIVARS

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Maize crop is highly susceptible to heavy metals toxicity particularly during the early growth stages. An experiment was carried out to unravel the coordinated effects of Pb (30mg/kg soil) and Cd stress (20mg/kg soil) on morpho-physiological growth, and oxidative metabolism in four maize cultivars (FH-949, FH-1231, DK-6142 and Malka-2016). Results indicates that Pb and Cd stresses severely reduced that root and shoot growth (length and biomass) of all the maize cultivars. However, such reductions were more severe under combined application of Pb and Cd stresses. Combined application of these stresses resulted in a further increase in cellular damage, correlating with an induction in the levels of reactive oxygen species and regulation of antioxidant enzymes (SOD, CAT and APX). Among maize cultivars, DK-6142 and Malka-2016 showed the less reduction in morphological growth, which was associated with better antioxidant activities and maintenance of photosynthetic pigments as compared with FH-949 and FH-1231 cultivar.

**Key Words:** cadmium, lead, maize, morpho-physiological growth, oxidative metabolism
INTERACTIVE EFFECT OF WATERLOGGING AND ARSENIC STRESSES ON MORPHO-PHYSIOLOGICAL GROWTH AND ARSENIC ACCUMULATION IN WHEAT

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Waterlogging and arsenic stresses are the two major factors affecting the crop growth and production worldwide, often occur together. While the individual effects of these stresses are studied in detail, the combined effects of these stresses are less understood. In this study, morpho-physiological growth and arsenic accumulation in wheat crop under the individual and combined waterlogging and arsenic stresses were studied. Different arsenic toxicity levels were 100, 200 and 300 mg kg⁻¹ soil. For imposing water logging stress, soil was kept saturated after 10 days of emergence. Waterlogging and arsenic stress significantly decreased plant biomass, chlorophyll content and relative water content in wheat, while the accumulation of reactive oxygen species and activities of antioxidant enzymes (SOD, POD, CAT, and APX) were increased. The adverse effects of the combined stresses were severe than the individual application of these stresses. The concentrations of arsenic in root and shoot were progressively increased with increasing the arsenic level particularly under waterlogged conditions. In short, co-occurrence of waterlogging and arsenic stresses caused more toxic effects on morphophysiological growth and enhanced arsenic accumulation in wheat as compared with the individual application of these stress.

Key Words: antioxidative defense system, arsenic toxicity, morpho-physiological growth, waterlogging, wheat
REMEDIATING EFFECT OF CHENOPODIUM QUINOA L. ON SALT EFFECTED SOILS

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Quinoa (Chenopodium quinoa L.) is an ancient Andean crop that produces edible seeds and leaves. Quinoa’s tolerance to salinity and other types of abiotic stresses provides it with high potential in a world where scarcity of water and increased soil salinization are important causes of crop failures. Quinoa is a facultative halophytic plant species with varieties being able to cope with salinity levels as high as those present in sea water (EC 40 dSm⁻¹ to 400 mM NaCl). In addition, being practically unique as a halophytic seed-producing crop with amazing nutritional properties. 100 g of quinoa grains has Moisture, ash, crude protein, crude fat, crude fiber and carbohydrate contents of quinoa seeds were ranged from 10.74 to 11.77%, 3.22 to 3.87%, 11.15 to 17.81%, 4.01 to 6.14%, 6.30 to 8.24 and 56.69 to 66.07%, respectively, In addition quinoa produce gluten free seeds. Under saline soil conditions, quinoa did not show any marked decrease in seed quality such as protein content, hardness, and density. Protein content even increased under high Na₂SO₄ concentration (32 dS m⁻¹) but total grain production decrease. This experiment was conducted at Dean office glass house University of Agriculture Faisalabad, Pakistan. This study includes 3 Salt stress levels (Control, EC=10 dsm⁻¹, EC= 20 dsm⁻¹) and Moringa leaf extract(MLE) spray. Salt stress created by NaCl. MLE sprayed three times. Then all growth and quality parameters measured, and Soil properties determined to check the Remediatng effect of Quinoa on salt affected soils. Results shows that MLE has positive effect on growth and grain yield of Quinoa under salts affected soils. Quinoa remediate soil due to root activity and facultative halophyte growth habit.

Key Words: Quinoa, Salts stress, Remediation, seed quality
COMPARATIVE STUDY OF FINE AND COARSE RICE VARIETIES TO ASSESS THEIR BEHAVIOR IN ARSENIC CONTAMINATED SOIL

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Arsenic is a toxic metalloid, carcinogenic and has becoming a globally emerging issue in Southeast Asian region, exist in two forms, arsenite (I) and arsenate(V). mostly peoples of Asian Countries, India, China, Bangladesh, Nepal and Pakistan rely on rice as staple food for their energy requirement. Rice is being cultivated in reduced environment and arsenite favors this and uptake is more as compare to arsenate(V). The objective of this comparative study is to grow different rice varieties in As stress soil and evaluate their potential against As. Seedbed is prepared and rice nursery after 30 days transplanted in pots in wire house of ISES, UAF, Pakistan. Ten different rice varieties, fine (5) and coarse (5) transplanted in As-contaminated pots (25 mg kg⁻¹). Growth parameter (number of tillers, plant height, number of spikelets, root, shoot and grains dry weight, flower emergence date etc.) of both side were taken. Results shows in growth parameter the fine varieties perform better as compare to coarse varieties, while the As uptake in fine varieties are more as compare to coarse varieties. The As uptake trends becomes in this order root > shoot > husk> grains in both (coarse and fine). Among all fine varieties Basmati-385 uptake more As while Basmati-198 show less accumulation. Whereas coarse variety KSK-282 accumulated higher As content and KSK-434 showed less accumulation. Overall As-accumulation is more in fine varieties while coarse varieties has potential to reduce the uptake of As.

Key Words: Arsenic · Contamination · rice varieties
RESPONSE OF SOILS BELONGING TO DIFFERENT CLIMATES TO FRESH ORGANIC MATTER INPUT

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Maintenance and restoration of soil organic matter is crucial for sustainable agriculture and climate change. The level of organic matter in soil depends on its addition in the form of above and below ground organic residue and its decomposition. Climate, land use, vegetation type, and soil physiochemical properties are identified as basic controls to govern the addition or decomposition of organic matter in soil. Knowledge on the mineralization of incoming residue and its fate under influence of different above-mentioned controlling factors is scarce and of utmost importance to predict long term trajectories of organic matter dynamics. This lab study is planned to investigate the role of added organic input in organic matter decomposition in soil of varying climate origin, land use and physiochemical properties. 39 days of incubation were done with six soils amended with uniform rate of cellulose extracted form C4 plant. According to results, cellulose addition resulted in increase in respiration rates in all soils. This increase was not uniform for all soils but strongly depending on soil physical characteristics e.g. EC (r=0.565), moisture (r=0.794). Additionally, a very strong positive (r=0.767) relationship was observed in respiration rate and recalcitrant fraction of already existing soil organic matter fraction. All four enzymes i.e. Chitinase, Glucosidase, Leucine and Acid phosphatase along with microbial biomass were also strongly related with climate parameters. Furthermore, Chitinase enzyme activity directly (r=0.61) influenced by recalcitrant fraction of already existing SOM and directly related with respiration (r=0.613). Mineralization rate found a sound positive relationship with oxidizable fraction (r=0.53) and fair positive with cellulose- amended increase in respiration rates (r=0.483). Both respiration and mineralization results showed that cellulose addition triggers decomposition of already existing organic matter as clear indication of positive priming effect at different rates that governed by climatic and soil physiochemical properties.

Key Words: Soil organic matter, Climate, Fresh organic matter, SOM Fractions, Soil extracellular enzymes
ARSENIC CONTAMINATION: HUMAN HEALTH RISK ASSESSMENT AND ITS TREATMENT

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Arsenic (As) occurs in both organic as well as inorganic forms in water and its pollution in water is a source of considerable concern for scientific and medical community. Major concerning issue with this metalloid is its carcinogenic activity. It can gain entry to body via contaminated water or by consuming As-contaminated crops and poses a serious and life-threatening risk to humans as well as livestock. A worldwide report has shown that As contaminated water directly affects more than 200 million people, globally. There is a dire need to employ various risk assessment frameworks and models to estimate its carcinogenic as well as non-carcinogenic effects on humans and livestock. Among these frameworks and models, US Environment Protection Agency’s (USEPA) equations are highly promising to assess the effects of As contaminated water on humans. These equations estimate carcinogenic and non-carcinogenic threats to humans and cover both oral as well as dermal exposure to As contamination. Similarly, risk due to the consumption of As contaminated food crops can be estimated by calculating estimated daily intake (EDI) of contaminated crops and exposure dose to these crops. A score of treatment strategies are employed to remove As from human food chain and include precipitation, coagulation, ion exchange, membrane filtration, flotation, phytoremediation and sorption etc. All these removal methods produce waste materials containing high concentrations of As and if these waste products are not properly disposed off, could be a source of environmental pollution. Various other strategies like traditional deep pits for disposal are not satisfactory. These drawbacks emphasize the need to develop new and hybrid technologies for the removal of As from environment and also to dispose off As containing sludge. So, the scientific community is expected to step forward and manage these challenges.

Key words: Arsenic, contamination, carcinogenic, treatment strategies, sludge
IMPACT OF BIOCHAR AMENDMENT AND NITROGEN FERTILIZATION ON GREENHOUSE GASES EMISSION FROM PADDY RICE

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Synthetic fertilizers are major drivers for inducing nitrous oxide (N₂O) emissions, and rice’s fields are primary source of methane (CH₄) fluxes. CH₄ and N₂O great potential to capture long-wave solar radiation, leading to warming of the globe. However, biochar amendments in agricultural soil is an appealing approach to mitigate N₂O and CH₄ emissions. So an attempt in current study was made to mitigate these greenhouse gases (GHGs) by biochar amendments and N fertilization in paddy rice under a controlled condition. In this study, 0, 2 and 4% (abbreviated as WBC, 2BC and 4BC, respectively) biochar were mixed in 3500 gm unsterile soil along with 0, 70 and 140 kg N ha⁻¹ (abbreviated as N₀, N₇₀ and N₁₄₀, respectively) before transplanting of rice seedlings. Each treatment was repeated three times in a completely randomized design (CRD). The results showed that the mean CH₄-C fluxes were ranged 1.21 to 1.28 µg CH₄-C cm⁻² d⁻¹ from pots treated with 2BC and 4BC, respectively, and this emission rate was 87-97% higher as relative to control treatment. Additionally, the application of 2BC and 4BC along with 70 kg N ha⁻¹ induced 112-132% and 35-40% higher CH₄-C emission rate over control and N₇₀ treatments, respectively. Furthermore, application of 2BC and 4BC along with 140 kg N ha⁻¹ induced 64-71% and 16-24% higher CH₄-C emission rate than control and N₁₄₀ treatments. The N fertilization treatments (N₇₀ and N₁₄₀) greatly accelerated 67-164% higher mean N₂O-N emission rate over control. The average N₂O-N emission were significantly reduced with addition of BC as compared to sole N fertilization treatments in soil of paddy rice during the whole growing period. The N₂O-N emission were ranged 0.13 to 0.17 µg N₂O-N cm⁻² d⁻¹ from pots treated with 4BC and 2BC, respectively; interestingly N₂O-N emission from 4BC was 18% low as compared to control treatment. In conclusion, biochar addition could reduce the N₂O emission even under higher N fertilization.

**Key words:** Synthetic fertilizers; nitrous oxide; methane; paddy rice
CLUSTERBEAN (CYNAMOPSIS TETRAGONOLOBA L.) LEGUME FORAGE FOR ENHANCING THE QUALITY OF MAIZE FODDER AT DIFFERENT FERTILIZATION REGIMES UNDER SEMI-ARID CONDITIONS

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Two years field trial was carried out at the research area of the Department of Agronomy University of Agriculture, Faisalabad to study the Agro qualitative response of cluster bean grown at different fertilization regimes in forage maize–cluster bean cropping system. Pre-sowing composite soil samples were collected from the experimental field up to a depth of 30 cm, and were analyzed for physico-chemical properties to assess the basic fertility status of the soil. Meteorological data for the growing period of the crop in both years were collected from the meteorological observatory of the department of Agronomy, University of Agriculture Faisalabad. Comparatively low rainfall was received in 1st year during the growth span of the crops. After the harvest of previous crop two fallow cultivations were given to the field there after presoaking (Rouni) irrigation was applied followed by a fine seedbed, prepared by cultivating field twice with a tractor-mounted cultivator, each followed by planking. Sowing of maize and cluster bean was accomplished with the help of single row hand drill. Maize was sown with a seed rate of 100 kg ha⁻¹ in 30 cm apart rows while the cluster bean was sown on the space between the maize rows using recommended seed rate of 50 kg ha⁻¹. The crop was given four irrigations each of 7.5 cm in both years. All other agronomic practices except the ones under study were kept normal and uniform for all the treatments. The experiment was comprised of different fertilizer levels viz. F0= 0-0-0, F1=150 kgNha⁻¹, F2=150-100 kgNPha⁻¹ and F3=150-100-100 kgNPKha⁻¹. The agronomic characteristics of cluster bean were significantly affected by different fertilizer application rates. Maximum fresh forage yield and dry matter yield was recorded where NPK was applied @ 150-100-100 kg ha⁻¹ sown in association with forage maize.

Key words: Forage maize, Clusterbean, NPK levels, Yield and quality.
ASSESSMENT OF GROUND WATER QUALITY WITH SPECIAL EMPHASIS ON CO-EXISTENCE OF BORON, SODIUM AND MAGNESIUM IN SOUTHERN PUNJAB OF PAKISTAN

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Under an arid and semi-arid environment, the source of irrigation water is an important approach to get reasonable crop yield. The irrigation water used by the farmers for crops is usually affected by the soluble salts, minerals and other ingredients in various concentrations. In Punjab, almost 75% of the ground water is considered unfit for irrigation as it contains high soluble salts and toxic heavy metals. Most common salts found in ground water are the sulfates, chlorides and carbonates of calcium, magnesium, sodium and potassium. The application of this saline water in the soil for crop production is causing severe problems of salinity and sodicity in the soil. Boron is an essential nutrient for plant body but is required in very minute quantity and its very little increase in plants causes severe damages in the plants. Sodium and magnesium toxicity also effect the reproductive and vegetative plant growth and cause sodicity and dispersion of soil aggregates and colloids.

Considering all above scenario, an assessment study was carried out for the fitness or unfitness of tube well water in the areas of district Vehari with special emphasis on boron, sodium and magnesium. Water samples were taken from given district and analysis in lab. Results showed that about 25 % water samples contained higher amounts of EC, TDS, calcium, magnesium chlorides and sodium. pH of all samples was found fit while SAR and RSC were also found satisfactory for most of the samples.

Keywords: Groundwater, Boron, Salts, Quality
SEASONAL CHANGES IN THE LEAF GUARD CELL CHARACTERISTICS OF FOUR AGAVE SPECIES

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Members of the family Agavaeacea represent CAM pathway of photosynthesis, which is known to occur in at least 25 angiosperm families, as well as a few gymnosperms and ferns species. These plants succulent, characterized by thickened stems and leaves modified for water and acid storage. An experiment was performed to explore the time course changes in length of epidermal cells, width of epidermal cells, length of guard cells, and width of guard cells, stomatal pore size and stomatal density in the leaves of four agave species including Agave americana, A. sisalana, A. horida and Yucca alifolia growing in the Botanical Garden, University of Agriculture, Faisalabad. The sampling for the leaf epidermis was done thrice a day i.e., at pre-dawn, mid-day and at dusk at an interval of one month starting from 24 November 2016. A large fluctuation was observed in the length and width of epidermal cells that it decreases gradually from November to January. The length of guard cells, width of guard cells, stomatal pore size and stomatal density showed a gradual decrease from November to January. These data revealed the distinct behavior of the stomatal characteristics, which improved our understanding the seasonal changes in the epidermal characteristics of the studied agave species.
GENOTYPIC VARIATION IN WHEAT IN RESPONSE TO SALINITY AND CADMIUM STRESS

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Salt stress is one of the major abiotic stresses for plants. Globally 20% of the irrigated arable land in semi-arid and arid zones are slightly to highly saline. Furthermore, heavy metal contamination in soil and surface water is increasing day by day. Wheat is usually titled as king of cereals and is grown on a large acreage in the world. An experiment was conducted in hydroponics to investigate the combined (NaCl+CdCl₂·H₂O) and separate effects of sodium chloride (NaCl) and cadmium chloride (CdCl₂·H₂O) on growth and physiological attributes of different genotypes of wheat (Triticum aestivum L.). Results indicated that the growth and biomass of roots and shoots declined gradually by applying stress on wheat separately or in combined (NaCl+CdCl₂·H₂O) form. The magnesium (Mg) and calcium (Ca) contents in shoots and roots were also decreased. Inhibition of the chlorophyll content was also observed specifically in upper parts of plant may be because of indirect effect of Cd on reduction of essential nutrients. Combined effect of NaCl+CdCl₂·H₂O was more as compared to separate application of CdCl₂·H₂O and NaCl. Response of CdCl₂·H₂O, NaCl and NaCl+CdCl₂·H₂O also depend on genotype of wheat.
The textile effluents contain the synthetic dyes which are mostly discharge into water bodies without any treatment. These dyes are harmful not only for aquatic life and microorganisms but also for human beings. These harmful effects become further severe due to the presence of metal ions along with the dyes. Hence there is need to deal these two types of pollutants at the same time. This study was aimed at isolation and characterization of bacterial strain exhibiting the potential to decolorize an azo dye Reactive Yellow 2 (RY2) in the presence of a metal ion zinc (Zn). For this study, Zn tolerant bacteria were isolated from a textile wastewater and tested for their potential to decolorize RY2. The most efficient strain, *Pseudomonas aeruginosa* strain LT10, was further characterized for its degrading capabilities under varying cultural and incubation conditions. This strain showed a good potential to decolorize RY2 and different other azo dyes (reactive black-5, reactive orange-16, reactive red-120, reactive yellow-2, congo red direct, orange direct) in the presence of Zn. The strain LT10 efficiently decolorized RY2 at pH 7.5 in the presence of yeast extract as a carbon co-substrate. Moreover, this strain also showed a good decolorization of RY2 even in the presence of high levels of NaCl along with Zn. Furthermore, this strain also showed a good tolerance against different metal ions. On the basis of this study, it is concluded that the strain LT10 might serve as an efficient bioresource for treating the textile wastewaters loaded with azo dyes and the metal ions.

**Key Words:** Synthetic dyes; Reactive Yellow 2; Decolorization; Bacteria; Zn Tolerance
EFFECT OF SILICON ON SOYBEAN (GLYCINE MAX L.) GROWTH UNDER CADMIUM STRESS

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Heavy metal contamination of soil has become a global environmental concern in industrial and urbanized areas all around the world. Pollution of agricultural soils due to heavy metals is a major problematic with the expansion of productions, mining activities, irrigation with waste water, therefore accumulation of heavy metals in crops is of great concern because of the possibility to enter the food chain. The assessment of potential bioavailable cadmium (Cd) fraction in soil is ultimately toxicity in the environment. Soybean is a main source of good quality protein and oil for human consumption and also used as biofuel and feed for livestock. Soybean is supreme prized global agronomic crop. A hydroponic experiment was conducted in the wire house of Saline Agriculture Research Center. University of Agriculture Faisalabad, to monitor the interactive effects of Silicon and cadmium on soybean growth. This experiment comprised of six treatments; T1: Control, T2: Si 2.0 mM, T3: Cd 0.2 mM, T4: Cd 0.4 mM, T5: Si 2.0 mM + Cd 0.2 mM, T6: Si 2.0 mM + Cd 0.4 mM. different parameters like shoot fresh weight shoot dry weight, chlorophyll content (SPAD value) and relative water content while concentration of CD and Si was measured. Each treatment was replicated three time according to Completely Randomized Design in factorial arrangement. The data of these parameters were analyzed statistically. It was concluded that combination application of Si showed positive effect on growth and yield of plants under Cd stress.

Key Words: Silicon; Cadmium stress; Soybean; Growth
EVALUATING THE TOXIC EFFECTS OF Zn, Ni AND Ag BASED NANOPARTICLES ON THE GROWTH AND PHYSIOLOGICAL PROPERTIES OF WHEAT

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The concentrations of metal oxide nanoparticles (NPs) have increased in environment due to higher use of NPs based products which is a major concern for food crops. Therefore, the present study was conducted to evaluate the toxic effects of zinc (Zn), nickel (Ni) and silver (Ag) based nanoparticles on the growth and physiological properties of wheat. For this purpose, a pot experiment was conducted in the growth chamber of the Department of Environmental Sciences and Engineering, Government College University Faisalabad, Pakistan. Different levels (0, 100, 500, 1000 mg kg⁻¹) of Zn-NPs, Ni-NPs and Ag-NPs were maintained in the pots containing 300g of soil. Hoagland solution was also applied to provide the basic nutrients. After 4 weeks of germination, plants from each pot were harvested. After harvesting, plants height, root and shoot length, root and shoot fresh and dry weight were measured. Chlorophyll contents were also measured using chlorophyll meter. According to the results, Ni-NPs and Ag-NPs exhibited significant reduction in growth, biomass and chlorophyll contents of wheat plants on all the applied levels as compared to control. However, Zn-NPs enhanced the plants growth and chlorophyll contents at 100 and 500 mg kg⁻¹ but further increase in concentration of Zn-NPs (1000 mg kg⁻¹) showed significant reduction in growth and chlorophyll contents of wheat. Further parameters such as antioxidants enzymatic activities, malondialdehyde contents (MDA), Electrolyte Leakage, H₂O₂ and metals uptake (Zn, Ni and Ag) by plants are under investigations.

Key Words: Nanoparticles; Toxicity; Wheat; Growth; Physiology
REMOVAL OF DYES FROM THE WASTEWATER USING BIOSYNTHESIZED NANOPARTICLES

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Disposal of untreated wastewater into water bodies is a common practice in developing countries which poses serious threats to the health and socioeconomic life of the mankind. Among the different methods used for treatment of textile wastewater, use of nanoparticles (NPs) synthesized by microbial organisms has attracted much attention worldwide. Specifically, bacteria which have ability to produce enzymes that reduce metal salts and help in synthesizing NPs (<100 nm in size) are a topic of interest for the scientific community worldwide. In this study, silver, zinc and nickel NPs were prepared and their morphology and surface characteristics were studied. Photocatalytic activity of the NPs was tested against methylene blue. Among the tested NPs, biosynthesized zinc oxide (ZnO) NPs performed best by degrading 95% of 0.5 mg mL⁻¹ methylene blue in 8 h compared to 18 h in case of chemically synthesized ZnO NPs with maximum degradation of 60%. The photocatalytic activity of the NPs was also examined by degrading other dyes under sunlight. Biosynthesized NPs effectively degraded nearly 95% of all the tested dyes in 24 h without the use of any reducing agent. Thus, biosynthesized nanoparticles can be a part of the solution to “Ensure availability and sustainable management of water and sanitation for all.”

Key Words: Nanoparticles; Bacteria; Biosynthesis; Dye reduction
IMPACT OF TREATED AND UN-TREATED REACTIVE BLACK-5 AZO-DYE ON GROWTH OF WHEAT

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A variety of synthetic dyestuffs released by the textile industry pose a threat to environmental safety. Azo dyes account for the majority of all dyestuffs produced because they are extensively used in the textile, paper, food, leather, cosmetics and pharmaceutical industries. The presence of azo dyes in the environment is one of the major concerns for food crops. The present study was conducted to evaluate the impact of different levels of treated and un-treated reactive black-5 azo dye on the growth of wheat in a pot experiment. Moreover, the impact of different levels of un-treated reactive black-5 azo dye on the growth of wheat was also evaluated in the presence of a dye decolorizing bacterial strain SG36. Different levels of the dye significantly reduced the root length, shoot length, root fresh weight and shoot fresh weight as compared to the control. However, these growth parameters were not significantly reduced when the wheat plants were applied with different levels of the treated reactive black-5 dye residues. Moreover, it was observed that the presence of the dye decolorizing strain SG36 in the soil medium resulted in amelioration of the toxic effect of the reactive black-5 azo dye.

Key Words: Synthetic dyes, Textile wastewater, reactive black-5 azo dye, bacterial strain SG36
CHARACTERIZATION OF BACTERIAL STRAINS CAPABLE OF SIMULTANEOUS REMOVAL OF HEXAVALENT CHROMIUM AND AZO-DYES ISOLATED FROM TANNERY WASTEWATER

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Disposal of untreated tannery effluents into the environment is a matter of great concern due to the presence of hexavalent chromium [Cr(VI)], dyes and salts. Previously, a number of microbial species have been reported for removal of heavy metals and dyes. However, very few work has been carried out to explore the potential of microbial species for simultaneous removal of Cr(VI) and dyes. In this context, the present study was conducted to isolate and characterize bacterial strains capable of simultaneous removal of Cr(VI) and dyes. For this purpose, tannery effluents were sampled from different locations in Kasur. About 56 bacterial strains were isolated from the collected tannery wastewater through enrichment culture technique. Based on the potential for simultaneous removal of Cr(VI) and reactive dyes, the most efficient bacterial strains were screened and selected for further study. The selected strain showed a good potential for simultaneous removal of dyes and Cr(VI) under slightly alkaline conditions and at a lower level of both the pollutants. Moreover, the presence of sodium chloride salt and the multi-metal mixtures resulted into a reduction in the simultaneous removal capabilities of the selected strains.

Key Words: Bacteria; Hexavalent Chromium; Azo-dyes; Simultaneous removal
CHARACTERIZATION OF NEWLY ISOLATED STRAIN YB4 CAPABLE OF SIMULTANEOUS REMOVAL OF CONGO RED AND HEXAVALENT CHROMIUM

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Microbial degradation is among the most suitable approach for removal of azo dyes from environment. But the presence of heavy metals hindered the activity of decolorizing microbes. This study was conducted to isolate the new microbes which have efficiency to decolorize the azo dyes in the presence of heavy metals. 100 isolates were isolated from the textile wastewater of Paharang drain and screened on the basis of their ability to decolorize the azo dyes. Among the tested strains, YB4 was found most efficient in decolorizing the azo dyes. The strain completely decolorized the different structured azo dyes (reactive black 5, reactive red 2, congo red). The strain YB4 was found efficient in complete removal of the congo red (200 mg L−1) and hexavalent chromium (10 mg L−1) simultaneously. While studying the impact of pH and NaCl content on decolorization, the strain YB4 showed complete decolorization and hexavalent chromium reduction at pH-8 and 10 g L−1 NaCl respectively. YB4 showed resistance against the presence of different heavy metals (Zn, Cd, Pd, Cr, Ni, Co), and also showed decolorization in the presence of different concentrations of these heavy metals. Then it is concluded that YB4 strain can be used as bioresource for the treatment of textile wastewater.

Key Words: Biodecolorization, Hexavalent Chromium Reduction, Textile Wastewater, C Sources
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ASSESSMENT OF ARSENIC CONTENT IN GROUNDWATER AND ASSOCIATED CARCINOGENIC RISK IN PERI-URBAN AREAS OF DISTRICT VEHARI, PAKISTAN

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Heavy metals are categorized as highly toxic pollutant by several world organizations. These metals are capable to exert many injurious health effects on humans by intake of metal-contaminated water. Therefore, the current study was planned to estimate the heavy metal concentration in groundwater used for drinking purpose in District Vehari. In total, 129 groundwater samples were collected from the peri-urban areas of District Vehari. Water samples were collected and analyzed for physiochemical parameters, cations, anions and heavy metals (lead, cadmium, nickel, chromium, zinc, manganese, copper and iron). Results indicated that the values of several groundwater parameters such as cation contents, alkalinity, chloride concentration and especially the levels of heavy metals such as Pb (93%), Cd (68%) and Fe (100%) were higher than their threshold given by WHO. The risk assessment parameters also showed possible carcinogenic risks associated with the ingestion of metal-contaminated groundwater at peri-urban areas of District Vehari, predominantly with Cd (0.0007-0.03). The mean HQ values for all the metals was < 1, while Pb showed HQ > 1 showing non-carcinogenic risk with the consumption of groundwater of District Vehari. Based on the results of the present study, it is anticipated that special monitoring and managements of drinking/ground water are necessary in the studied area in order to curtail the health risks associated with the use of metal-contaminated drinking water. Moreover, appropriate remediation and removal of heavy metals from drinking/ground water are also imperative for the study area.

Key Words: Groundwater, Heavy metals, Contamination, Risk assessment
Despite considerable development in the recent past, the data regarding foliar uptake of lead (Pb) as well as the associated bio-physio-chemical changes inside plants and associated health hazards are limited. The current study determined the effect of foliar application of Pb nanoparticles (Pb-NPs) on Pb accumulation, physiological and biochemical changes inside spinach plants and associated health risks of consuming Pb-contaminated spinach. Lead NPs were prepared by green method using lead acetate and coconut water as a reducing agent. The SEM analysis confirmed the preparation of smooth, unwrinkled, granular and spherical PbO-NPs. Spinach seedlings were grown hydroponically and exposed via foliar brush application to 3 levels of Pb-NPs (0, 10 and 50 mg/plant). Foliar Pb-NPs application resulted in significant accumulation of Pb in leaves, with limited translocation to root tissues. As toxicity indices, foliar Pb application cause significant decrease in pigment contents (38%) and dry weight (67%). After foliar uptake, Pb caused several folds increase in the activities of antioxidant enzymes. However, foliar Pb-NPs did not induce significant changes in H$_2$O$_2$ production and lipid peroxidation. The highest level of Pb-NPs showed possible human health risks due to consumption of Pb-contaminated leaves of spinach. Therefore, based on the results of current study, it is proposed that atmospheric contamination and foliar deposition of metal-PM can seriously affect vegetable growth and can induce human health risk from the consumption of contaminated plants.

**Key Words:** Pb nanoparticles; foliar uptake; bio-physio-chemical changes; risk assessment; human health
HEALTH RISK ASSESSMENT OF HEAVY METALS VIA DIETARY INTAKE OF CROP/VEGETABLES IRRIGATED WITH UNTREATED CITY WASTEWATER IN DISTRICT VEHARI

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In district Vehari, farmers are using untreated city wastewater for crop irrigation owing to the shortage of good quality water. The present study evaluated the potential impacts of wastewater irrigation on vegetables, as well as the concentration of potential toxic metals (PTMs) at different stages of their entrance to food chain which include; soil and vegetable and the risk assessment for human beings. The present study evaluated the potential impacts of wastewater irrigation on metals (such as Pb, Cd, Ni, Cu, Cr, Mn, Zn and Fe) buildup in the soil-plant system. In this study, wastewater (n = 17), soil (n = 108) and plant (n = 65) samples were collected from 15 peri-urban sites of three tehsils of district Vehari. Results showed that the mean concentration (mg/L) of Cd (0.02), Mn (0.25) and Fe (1.57) in wastewater samples was higher than their respective threshold values. Similarly, Cd, Mn and Fe concentration in soil were beyond the permissible limits of agricultural soil after wastewater irrigation. However, plants showed high accumulation of Pb, Cr and Fe than their respective limits depending on the vegetable/crop species. The health risk parameters showed that Pb and Cd are major toxic chemical substance to human health and the daily intake of crop plants can pose a potential health threat due to wastewater irrigated crop consumption. Our results emphasized the need for pretreatment of wastewater to avoid the soil and vegetable contamination by wastewater irrigation system and furthermore to reduce the associated health risks.

Key Words: Wastewater irrigation, potential toxic metals, crops, vegetables, human health risk
WASTEWATER IRRIGATION EFFECT ON ZINC AND CADMIUM ACCUMULATION IN VEGETABLE ENVIRONMENTAL CONSEQUENCES AND HEALTH RISK ASSESSMENT

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In District Vehari, untreated wastewater is extensively used for agricultural practices owing to the shortage of good quality water. It is well-known that wastewater contains numerous organic and inorganic contaminants including heavy metals. The current study evaluated the impact of wastewater irrigation on metal accumulation (Cd and Zn) in vegetable and associated health effects. Wastewater samples were collected from three wastewater disposal sites of Vehari District. A pot experiment was conducted and three widely cultivated vegetables (radish, spinach and cauliflower) were sown and irrigated with wastewaters. Results indicated that application of wastewaters increased Cd and Zn concentration in all vegetables. Significant Cd and Zn enrichment (1.1-7.4 and 7-7.38 respectively) was observed for vegetables irrigated with wastewater. Zinc content in vegetable shoots was 1.9-12.72 mg/kg and roots 1.81-16.60 mg/kg, respectively. Total Cd contents in vegetable shoots (5.34-35.45 mg/kg) and roots (1.81-42.88 mg/kg) were higher than the permissible Cd limit by FAO (5-30 mg/kg). Health Risk Index (HRI) of Cd was > 1 for all vegetables; spinach presented the maximum HRI among the vegetables. While Health Risk Index (HRI) of Zn was <1 for all vegetables. Findings of our study emphasized the need for treatment of Vehari city wastewater prior to its use for vegetable irrigation to avoid metal-contamination soil and vegetable.

Key Words: Wastewater irrigation, Cadmium, Zinc, Vegetable, Health risk.
ACCELERATED PHYTOEXTRACTION OF SOILS HAVING CONTAMINATION OF ARSENIC AND CADMIUM

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Various toxic heavy metals including arsenic (As) and cadmium (Cd) could not be destroyed and elimination of elevated level of such metals especially from soil is necessary as such contaminated soils represent potential ecological and human health risks. Phytoextraction is one of the strategies of phytoremediation, refers to the uptake and translocation of metal contaminants in soil by plants’ roots into above ground parts of the plants. Metal hyperaccumulator plants have the ability to remove metals from polluted soils. The present study has been designed to estimate the potential of mungbean (Vigna radiate L.) and sorghum (Sorghum bicolor L.) for the extraction of arsenic and cadmium. Efficiency of selected hyperaccumulator plants was evaluated for phytoextraction potential of cadmium and arsenic in contaminated soil. Seeds of selected plants were sown in pots where contaminated environment was created by irrigating the soil with different integrated mixtures of As (0, 100 ppm, 200 ppm) and Cd (0, 200 ppm). NPK fertilizers were applied in appropriate doses. Data regarding physiological growth (i.e., root length, shoot length and biomass) under various concentrations of cadmium and arsenic were collected at maturity. The concentration of cadmium and arsenic in the soil was also analyzed by using atomic absorption spectrophotometer. Outcome regarding phytoextraction performance of sorghum and mungbean was also estimated under stressed environment. Standardized statistical methods were followed to analyze the experimental results. Finally, the capability of mungbean and sorghum as hyperaccumulator for arsenic and cadmium was also determined.

Key Words: Phytoextraction; Arsenic; Cadmium; Sorghum; Mungbean
ASSESSMENT OF ARSENIC CONTAMINATION IN GROUNDWATER AND ITS REMEDIATION USING IRON-BASED SORBENTS

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Arsenic (As) is a toxic metalloid and classified as Class-I human carcinogen. Arsenic exists in two forms, arsenate (As⁵⁺) and arsenite (As³⁺). Arsenite is more toxic form then arsenate. More than 200 million people worldwide are at risk of As poisoning. According to recommendations of WHO, the permissible limit of As in drinking water is 10 μg L⁻¹. Elevated concentration of As is found in groundwater of many countries. To remove As from groundwater, many technologies has been used that includes oxidation, phytoremediation, coagulation – flocculation, membrane technologies, ion exchange, electrokinetics and adsorption. Among these, adsorption process has been used most widely because of its high removal efficiency, easy operation and handling, low cost and sludge-free. This review highlights the effect of iron-based sorbents, zero valent iron, indigenous filters, cartridges and various adsorbents on As adsorption. Adsorption on iron-based sorbents (IBS) is an emerging treatment technique for As removal. Removal of As has been attributed to ion exchange, specific adsorption to surface hydroxyl groups or co-precipitation. Different iron based sorbents that can be used in adsorption process include granular ferric hydroxide (GFH), iron coated sand, hydrous ferric oxide (HFO), polymorphs of iron hydroxy-oxide mineral (FeO(OH)) and Fe₃O₄ (magnetite). Use of Fe-based sorbents is the best mechanism to remove arsenic from groundwater.

**Key words:** Arsenic remediation, iron based sorbents
UTILIZING OIL DEGRADING BACTERIAL ISOLATES FOR GROWTH PROMOTION OF MAIZE (ZEA MAYS L.)

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Increasing population of the world has made it inevitable to utilize marginal lands for crop production to ensure food security. Soil pollution with crude oil due to pipeline rupture, tank failures, various production and storage problems and transportation accidents is becoming a widespread environmental issue. The present study was aimed to screen an efficient bacterial isolate from oil contaminated sites which not only degrade oil but also help to support growth of the crop grown on soil contaminated with oil.

From a total of 20 bacterial isolates obtained from two different hydrocarbons contaminated samples, four isolates namely FSD1, FSD2, MG1 and MG2 were selected as efficient crude oil degraders with respect to their growth on crude oil enriched samples. The selected isolates were tested for their plant growth promoting attributes like phosphate solubilization, Exopolysaccharide production, Indole Acetic Acid (IAA) and Hydrogen Cyanide (HCN) production, and growth performance. Furthermore, these isolates were used for Maize seed inoculation and a jar trial was conducted in which soil was artificially contaminated with 0 ppm, 1000 ppm and 2000 ppm total petroleum hydrocarbons. Results revealed that Maize seeds inoculated with MG2 was most efficient in oil degrading and Maize growth promotion in jar trail. 16S RNA sequencing revealed that MG2 isolate belongs to Phyla Proteobacteria, genera Enterobacter and has 99% sequence similarity with Specie cloacae. This isolate might be used as consortium for growing crops in oil contaminated fields.

Keyword: PGPR, Exopolysaccharides, P-solubilizing
Widespread occurrence of antibiotics and antibiotic resistant bacteria in environmental matrices is posing a serious threat to public health worldwide. Since, the significance of bacterial isolates from environmental samples as a reservoir of antibiotic resistance is not well documented in Pakistan, therefore the aim of present study was to isolate and characterize bacterial strains from wastewater channels in vicinity of pharmaceutical industries and hospitals of Islamabad, Rawalpindi and Faisalabad, to inspect the presence of antibiotic resistant microorganisms. Antibiotic susceptibility of 109 isolated strains was monitored according to the Kirby – Bauer disc diffusion method against five most commonly used antibiotics. Results of this study indicated that amongst all tested antibiotics, Ampicillin and Levofloxacin resistance had the highest and lowest frequency respectively. 92.0% were resistant to Ampicillin, 83.5% to Amoxicillin, 67.0% to Ofloxacin, 21.1% to Levofloxacin and 28.0% were resistant to Ciprofloxacin. 30.3% of the strains showed resistance to more than three drugs. Maximum resistance was observed in species from the genus *Escherichia* (57.1%), *Aeromonas* (56.3%), *Acinetobacter* (41.2%), *Proteus* (14.0%), *Pseudomonas* (8.3%), *Shewanella* (25.0%) while *Citrobacter sp.*, *Comamonas sp.*, *Bacillus sp.*, *Alishewanella sp.* showed 100% resistance to all the tested antibiotics. Incidence of Ciprofloxacin resistance in *Acinetobacter*, *E. coli* and *Aeromonas* was higher than Levofloxacin resistance, while Levofloxacin showed intermediate resistance to a large number of isolates. The results of present study confirms presence of multidrug resistant isolates in wastewater streams of Pakistan which may lead to the spread of antibiotic resistance and ultimately becoming the reason of treatment failures.

**Keywords:** Antibiotics, Antibiotic resistance, Multi-drug resistance, Pharmaceutical
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PHOSPHOROUS DYNAMICS IN TWO DIFFERENT SOIL SERIES OF PAKISTAN CULTIVATED WITH MAIZE (ZEA MAYS L.)

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A study was conducted to understand the P dynamics maize hybrid (NT6221) was cultivated with two different soil series (Bahawalpur and Lyallpur) of Pakistan at different P sources and application rates. A pot experiment was conducted in the wire house of Institute of Soil and Environmental Sciences, University of Agriculture Faisalabad. Each Pot with 6 kg of soil had controlled treatment, two level of Diammonium phosphate (DAP), @ 648 mg kg⁻¹ and 324 mg kg⁻¹ of soil and two levels of Triple superphosphate (TSP), @ 900 mg kg⁻¹ and 450 mg kg⁻¹ of soil as source of P. Each treatment was replicated three times. Soil analysis (soil texture, particle size distribution, pH, EC, total soluble salts, CaCO₃, saturation percentage, available K, available P) and agronomics parameters (plant biomass, shoot fresh weight, shoot dry weight, root fresh weight, root dry weight, root length and shoot length) was analysed to determine P dynamics in two soil series of Pakistan and to evaluate P source use efficiency in maize. Data obtained was analysed by using CRD factorial design to evaluate response of treatments. In case of soil series, the results showed that Lyallpur soil series performed better than Bahawalpur soil series. In case of P source and application rates, half dose of both fertilizer (DAP and TSP) gave same response as that of full doses applied and showed better absorption in roots and shoots as compared to other treatments applied. P was recorded to be more available to plants in Lyallpur soil series while Bahawalpur soil series with high amount of clay showed more adsorption of P.

Keywords: Phosphorous, Alluvial, DAP, Soil Series
DETREMENTAL EFFECT OF BIOSOLIDS APPLICATION ON SOIL AND AQUATIC ENVIRONMENT

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In agriculture landfilling of biosolids cause determinantal effect on plants, soil and aquatic environment. Biosolids are major source of heavy metal contamination in agricultural lands. Biosolid comes from municipal wastage treatment as a by-product mixture of nutrients, minerals and organic materials. Risk assessment is complex because sludge contain high amount of organic chemicals, toxic metals, chemical irritant and pathogens. The effect of their interactions, long-term build-up in soil, leaching in waterways and uptake by crops. Nitrate leaching in ground water cause blue baby syndrome leaded by methemoglobinemia, pathogens cause disease like Hepatitis A, E.coli Diarrhea etc. Generally industrial wastages have more pollutants organic or inorganic than household sewage sludge. In a long-term, specifically heavy metals behaviour before and after application of biosolids in soils still unknown. In soil adsorption reaction, heavy metals may be adsorbed via specific or non-specific. Heavy metals speciation and adsorption may be affected due to the presence of competing ions, also pH and CEC of soil. In solution, heavy metals present either as free-ions or complex with organic and inorganic ligands. Generally, soluble or free ions are more available to plants. So, environmental pollution study more relevant to free or soluble ions and in future require more efficient technology to remove the hazardous pollutants from biosolids.

Key words: Adsorption, sewage sludge, organic matter, pH
The major part of Pakistan’s economy comes from its agriculture sector. In Pakistan wheat is one of the most vital cereal grains because it is the main staple food and contributes 1.7 percent to GDP. There are different factors that contribute to reduce the wheat yield; among them weed infestation is one of the most important factors responsible for 20-30% of yield loss. Different approaches are adopted to control weeds i.e. physical, mechanical, chemical and biological. All these methods have several limitations and consequences except the biological one which is environmentally friendly. To reduce chemical herbicides load, recent research is being focused on integrated use of chemical herbicide with biological weed control. For this purpose, a jar trial study was planned using pre-isolated and pre-characterized allelopathic bacterial strains taken from Soil Microbiology and Biochemistry Laboratory, Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad. These strains were tested against various herbicides for survival at different dosage. The compatible combinations of the best strains C1 (WF1xWF4), C2 (WF2 x WF3), C3 (WF1 x WF3 x WF4) and C4 (WF1 x WF2 x WF3 x WF4) were applied through seed priming along with chemical herbicides (e.g. Atlantis and Axial @ 25 and 50% of the recommended doses) under axenic conditions to test the Phalaris minor suppression. In another jar trial under axenic conditions, the wheat growth promotion by allelopathic bacteria was also checked where wheat seeds were inoculated with selected strains. Phalaris minor and wheat were grown for 30 days on glass jar in growth room of Soil Microbiology and Biochemistry Lab. Results showed that integration of C4 bacterial strains with axial 25% of the recommended dose reduced the Phalaris minor germination by up to 73%. While shoot and root lengths of Phalaris minor were reduced up to 49% and 75%, respectively. The growth of wheat was significantly improved by C4 strain inoculation while the effect of other strains was at par with C4.
THERMODYNAMICS OF 2,4-DICHLOROPHENOL REMOVAL FROM THE AQUEOUS MEDIA USING BIOCOMPOSITES

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The aim of the current study is to constructively utilize barley husk (BH) and its biocomposites for the adsorptive removal of 2,4-DCP (2,4-Dichlorophenol) from simulated waste water. The effect of different process parameters such as initial pH, temperature, BH dose, initial 2,4-DCP concentration and contact time on 2,4-DCP percentage removal was evaluated. Maximum 2,4-DCP removal (%) of about 23.09% was perceived at pH of 7.0, temperature 30°C and contact time of 120 min. By using equilibrium constant at different temperature, thermodynamics constant of adsorption like ΔG, ΔH and ΔS were also calculated. The value of ΔH showed that the reaction was exothermic in nature. Different sorption isotherms like Langmuir and Freundlich were employed on exploratory data. It was noticed that Freundlich isotherm was fitted well with the attained results. The FTIR results confirmed the presence of different groups like phenolic and cellulosic on the surface of native and composites sorbents. Results showed that BH waste biosorbent could be promising for pesticide removal from contaminated waste water.

Key Words: 2,4-Dichlorophenol, Biosorption, biocomposites, batch study, thermodynamics study
SOIL-PLANT-MICROBE INTERACTION FOR IMPROVING GROWTH AND YIELD OF WHEAT (TRITICAUM AESTIVUM L.) IN STRESSED AGRICULTURE MANAGEMENT

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Salt stress is a critical factor in plants that severely affects plant growth and metabolism. Salinity stress involves complex and variable mechanisms that related to different metabolic pathways of various organs. Several parameters have been developed to evaluate the salt tolerance. The role of soil-plant-microbe interactions along with organic manure helps in solving stressed agriculture problems. Beneficial microbes associated with plants are known to stimulate plant growth and enhance plant resistance to biotic (diseases) and abiotic (salinity, drought, pollutions, etc.) stresses. By keeping in view this scenario it is hypothesized that the use of Plant Growth Promoting Rhizobacteria Bacillus Sp. and organic manure play vital roles in the maintenance of plant fitness and soil health under stressed environments. The application of organic manure as a soil conditioner to stressed soils along with suitable microbial strains could further enhance the plant-microbe associations and increase the crop yield. For this purpose a pot experiment was conducted to check the effect of organic manure and Bacillus Sp. for improving growth, yield and nutrient uptake of maize under saline conditions. The salinity levels (ECe 0, 5, and 10 dS m⁻¹) were developed using NaCl salt. Treatment plan was consist of salt stress along with Bacillus Sp. and organic manure (3.5%). Results showed that salinity negatively influenced growth and yield of maize. Application of organic manure and bacterial strain Bacillus Sp. significantly improved root-shoot length and biomass, photosynthesis, transpiration rate, relative water content and yield of wheat under salt stress conditions. Similarly, higher uptake in NPK was observed through combined application of organic manure and Bacillus Sp. as compared to control. The finding of the study revealed that organic manure along with Bacillus Sp. could be used to enhance growth and yield of maize under saline conditions.

Key Words: Beneficial microbes, organic manure, plant growth, plant growth promoting rhizobacteria, salinity.
FUNGI AS ENVIRONMENT CLEANER: NEED OF PRESENT ERA

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Nowadays, environment is continuously being loaded by the huge number of contaminants as result of industrialization and population expansion. Many traditional physico-chemical means are adopted to reduce the toxic effects of pollutants. However, the use of fungal potential as environment cleaner is recognized as a green route to clean up the polluted sites. It is an eco-friendly and cost-effective approach to degrade the pollutants by application of several biological processes. In this technique, beneficial fungal species are utilized in polluted systems that have unique ability to degrade the contaminants by various means including the different enzymes like laccases, cytochrome P450 monooxygenases, catalases and peroxidases. Fungi can also survive in diverse habitat even under extreme environmental condition. So, the multiplicity of habitats along with the production of multitude enzymes makes it a significant biological candidate for environment cleaning. In this regard, different fungal species belong to different genera for instance, Trichoderma, Aspergillus, Fusarium, Mucor, Curvularia, Rhizopus and Pythium have been investigated that can reduce the risk of pollution produced from various means like textile dyes, petroleum, pesticides, pharmaceuticals, leather tanning industries, textile wastes and effluents from textile etc. Although, the role of fungi in degrading of waste material has been explored but some areas like degradation pathways are still not fully understood. Recent advancement in molecular biology can be helpful to develop a better understanding of degradation pathways and through genomic studies, genes can be identified as well expressed in various other biological systems that can assist to clean the environment.

Key Words: Pollution, environment, fungi, enzymes, cleaning
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