Microbiology: An International Journal

Review | Vol 2 Iss 2

Biosorption of Lead by *Azadirachta indica*

Tyagi S and Tyagi A*

Department of Biotechnology, Meerut Institute of Engineering and Technology, Meerut, Uttar Pradesh, India

***Corresponding author:** Anjali Tyagi, Department of Biotechnology, Meerut Institute of Engineering and Technology, Meerut, Uttar Pradesh, India, E-mail: anjalitg22@gmail.com

Received: March 27, 2017; **Accepted:** May 19, 2017; **Published:** May 26, 2017

Abstract

Lead is a microelement naturally occurs in trace amounts in all biological materials, i.e. in soil, water, plants and animals. It has no physiological function in the organism According to Cibulka, the main source of lead contamination are smelting works, application of wastewater treatment sludge to soil, transportation, rain, snow, hail and other. Approximately 98% of lead in the atmosphere is from human activities. Neumann et al. have extended the sources of lead pollution by paints, lead wastes, cell batteries, lead solders and forms. Lead is absorbed through plants through roots where most of the lead is also accumulated. In the case of other than root uptake (along roads in urban regions) the content of lead decreases as follows: above ground part > roots > products Intoxication of animals by lead occurs particularly after grazing on pasture contaminated with lead .Lead enters the organism with food and air. In children it affects most the central nervous system. The toxic effects of lead in the prenatal stage cause a shortening of gravidity.

Keywords: **Plant biotechnology, Biosorption, Microbial ecology, Metal selective, Antifeedant**

Introduction

Development in Plant Biotechnology & Environmental Biotechnology gives rise to relatively new field of science and technology, discussing in 2nd International conference on Plant Science & Physiology, June26-28, 2017 Bangkok, Thailand & Environmental Toxicology October 19-20,2017 Atlanta, USA.

Plant biotechnology is a scientific technique that adapts plants for specific purposes by cross breeding, extending their growing seasons, adjusting heights, color & texture & several other mechanisms [1-10].

Biotechnology is the use of living system & organisms to develop or make products or any technological application that uses biological system, living organisms & derivative thereof, to make or modify products or processes for specific uses.

Green Biotechnology is defined as the utilization of biological techniques to plants [11-14] with the aim of improving the nutritional quality, quantity & production economics.

Plant Biotechnology has created unprecedented opportunities for the manipulation of biological system of plants. To understand biotechnology [15], it is essential to know the basic aspects of genes & their organization in the genome of plant cells. To increase the development studies in field of microbiology certain research associations are coming together to support new and challenging approaches using microbiological factors such as European Biotechnology Thematic Network Association (EBTNA) which aims to utilize Biotechnology and Microbiology tools for different applications in field of

Medical, Environment, Healthcare, and Microbiology [16-21]. The advantage of Plant Biotechnology includes curing infectious diseases, increasing farming yields. It may provide the solution to many major global issues, including world hunger, global warming & pollution [22].

Lead (Heavy Metal)

A heavy metal is a metallic component which is toxic and has a high density, specific gravity or atomic weight. Less commonly, any metal with a potential negative health effect or environmental impact may be termed a heavy metal [23], examples of heavy metals include lead, mercury, cadmium, cobalt, chromium, lithium and even iron. The important metals, Mercury, lead, cadmium, Arsenic and Chromium (VI) are regarded as harmful; whereas, others, such as copper, nickel, cobalt and zinc are not as toxic [24-27]. The heavy metal ions are detected in the waste streams from mining operations, tanneries, electronics, electroplating, batteries and petrochemicals [28] companies. They have harmful impact on human physiology and other biological systems when they exceed the tolerance levels. Lead deposited on the ground is transferred to the upper layers of the soil surface, where it may be retained for a long time (up to 2000 years). In undisturbed ecosystems, natural matter in the upper layer of soil surface retains environmental lead. In cultivated soils, this lead is mixed with soil to a depth of 25C1ll (i.e., within the root zone). Atmospheric lead in the soil will start to move into the micro-organism and grazing food chains, until equilibrium is reached. To highlight innovative researches in field of microbiology and environmental concern a number of research work published under different Journals such as Bioremediation & Biodegradation, Expert Opinion on Environmental Biology and many more. All the write-ups submitted to the Journals provide a range of individual opportunities to acknowledge internationally.

Plants on land tend to absorb lead from the soil and retain most of this in their roots. There is some proves that plant foliage may also take up lead (and it is conceivable that this lead is moved to different parts of the plant). The uptake of lead by the roots of the plant may be reduced with the exposure of calcium and phosphorus to the soil [29-31]. A few types of plant have the capacity to accumulate high concentrations of lead. Lead at the toxic concentrations occasionally found near roadsides (i.e., 10,000-40,000 ppm dry weight), can wipe out populations of bacteria and fungi on leaf surfaces and in soil. This can have a significant impact, given that many of these micro-organisms are a fundamental part of the decomposing food chain. The micro-organism populations [32-40] influenced are likely to be replaced by others of the same or different species, although these may be less effective at decomposing organic matter. Evidence also proposes that micro-organisms can make lead more soluble and hence more easily absorbed by plants. Lead affects the central nervous system of animals and inhibits their capacity to synthesize red blood cells. Lead blood concentrations of above 40µg/dl can produce observable clinical symptoms in domestic animals. Lead has many different impacts e.g. acute abdominal pain, kidney damage, high blood pressure and adverse reproductive consequences etc. [41-45]. Lead salts enter the environment through the exhausts of cars, autos. The larger particles will drop to the ground immediately and contaminate soils or surface waters, the smaller particles will travel long distances through air and stay in the atmosphere. Part of this lead will fall back on earth when it is raining. This lead-cycle [46] caused by human creation is much more extended than the natural lead-cycle. It has caused lead pollution to be a worldwide issue. Lead can cause several unwanted effects [47], such as:

- Disruption of the bio-production of hemoglobin and anemia
- A rise in blood pressure
- Kidney damage
- Miscarriages and subtle abortions

- Disruption of sensory systems
- Brain harm
- Declined fertility of men through sperm damage
- Decreased learning abilities of children
- Behavioral disruptions of children, such as aggression, impulsive behavior and hyperactivity

The presence of metal ions in final industrial effluents is extremely unwanted, as they are toxic to both lower and higher organisms [48]. Under certain natural conditions, metals may accumulate to lethal levels and cause ecological damage.

Major lead pollution can occur through automobiles and battery manufacturing. Lead particles that settle on the soil from leaded gasoline or paint can keep going for a considerable length of time. Lead-contaminated soil is still a noteworthy problem around highways and in some urban settings. Household dust can contain lead from lead paint chips or from contaminated soil brought in from outside. Glazes found on some ceramics, china and porcelain can contain lead that may leach into food. Heavy metals are toxic to aquatic organisms [49-55] even at very low focus. Most of these minerals were present in our surroundings only in minute amounts until recent centuries, when the orientation toward industrialization and production brought about our numerous technological advances. But technology, like medicine, has its side effects. At present, these harmful metals have polluted our atmosphere, our waters, our soil, and food chain. Approximately 98% of lead in the atmosphere is from human activities. Neumann et al. have extended the sources of lead pollution by paints, lead wastes, cell batteries, lead solders and forms.

Azadirachta indica **(Neem)**

Other name of *Azadirachta indica*, are Neem, Nimtree, and Indian Lilac is a tree in the mahogany family Meliaceae. It is one of two species in the genus Azadirachta, and is native to India, Pakistan, and Bangladesh developing in tropical and semi-tropical regions. Neem tree is the official tree of the Sindh Province and is very common in all cities of Sindh, there are projects underway for planting this tree in all over Sindh Province [56-60].

Neem is a life giving tree, especially for the dry coastal, southern districts. It is one of the very few shade-giving trees that thrive in the drought prone zones. The trees are not at all delicate about the water quality and thrive on the merest trickle of water, whatever the quality. In very dry areas like Sivakasi, the trees are planted in large tracts of land, in whose shade fireworks companies function [61-70]. The biosorption of Pb(II), Cd(II) and Cr(III) by neem leaf under various conditions. The pH has much effect on the biosorption of these metal ions from watery solutions. The rate of the biosorption of these metal ions followed pseudo- second-order and Elovish kinetic models, with the former having better regression coefficients than the latter. The sorption isotherms of these metal ions onto the biosorbent [71-76] are well described by the Freundlich and Langmuir isotherm models.

Azadirachta indica is a fast-growing tree that can reach a height of 15-20m (49-66 ft.), rarely to 35-40m (115-130 ft.). It is evergreen, but in severe drought it may shed most or nearly all of its leaves. The branches are wide and spreading. The genuinely dense crown is roundish and may reach a diameter of 15-25m (49-70 ft.) in old, free-standing specimens. The neem tree is very similar in appearance to its relative, the Chinaberry (*Melia azedarach*) [77-82].

FIG 1: Neem (*Azadirachta indica*) leaves

The Neem tree is noted for its drought resistance. Normally it thrives in areas with sub-arid to sub-humid conditions, with a yearly rainfall between 400 and 1200 mm. It can grow in regions with a yearly rainfall below 400 mm, but in such cases it depends largely on ground water levels. *Azadirachta indica* can grow in many different types of soil, but it thrives best on well drained deep and sandy soils [83-89]. It is a typical tropical to subtropical tree and exists at yearly mean temperatures between 21-32°C. It can tolerate high to very high temperatures and does not tolerate temperature below 4°C.

Azadirachtin from *Azadirachta indica* effects insects in a variety of different ways: as an antifeedent, insect growth regulator and sterilant. As antifeedant sensitivity varies greatly between insects the overriding efficacy of *Azadirachta indica* insecticide use lies in its physiological toxic effects [90-96]. An understanding of the physiological effects of azadirachtin in neem has been reached and biochemical approaches have begun to define its method of activity at the cellular level. Further work is however required to fully understand its mode of action.

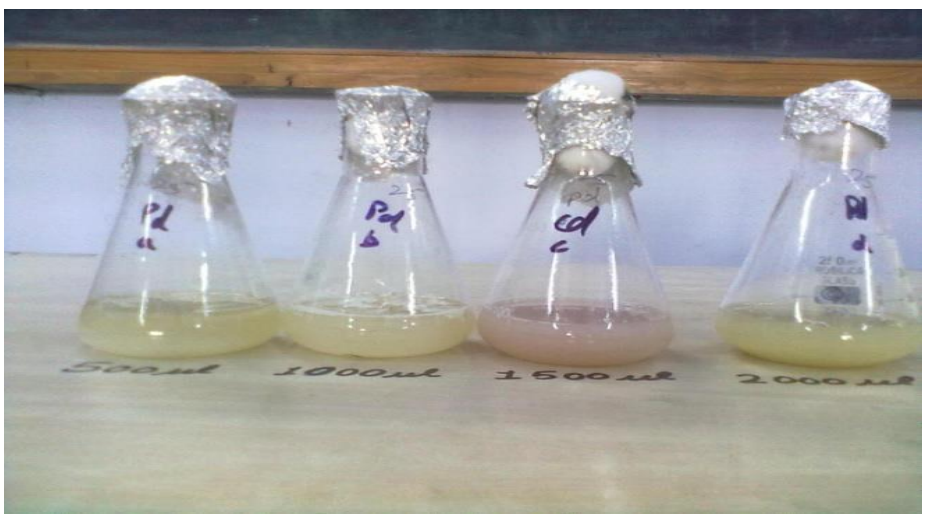

FIG 2: Flasks of Pb (25ppm) innoculated with neem extract in combination in different amount.

Conclusion

Development of Plant Biotechnology in coming current years will have a broad spectrum of application, usage and can serves to save a large range of pollution. The new technique has no side effects & will be more effective than previous techniques for removing several heavy metals from environment. Looking upon the development of Plant Biotechnology scientist and researchers need to accelerate in India [97-104]. In India we should take appropriate steps to develop Plant Biotechnology & Environment Biotechnology such as ICAR- National Research Centre on Plant Biotechnology, Agricultural College and

Research Institute-Killikulam, Govind Ballabh Pant University of Agriculture and Technology, Institute of Forest Genetics and Tree Breeding, Coimbatore, Tamil Nadu, The Council of Scientific & Industrial Research (CSIR), New Delhi.

REFERENCE

1. Elekwachi CO. Global Use of Bioremediation Technologies for Decontamination of Ecosystems. J Bioremed Biodeg 2014;5(225).
2. Abid A. Feasibility of a Bioremediation Process Using Biostimulation with Inorganic Nutrient NPK for Hydrocarbon Contaminated Soil in Tunisia. J Bioremed Biodeg 2014;5(224).
3. Tandlich R. The “Old-New” Challenges of Water, Sanitation and Bioremediation in Developing Countries. J Bioremed Biodeg 2014;5(e152).
4. Bhatt SM, Shilpa, Sidhu M, et al. Scope of In-situ Bioremediation for Polluted Aquifers via Bioaugmentation. J Bioremed Biodeg 2014;5(e150).
5. Olawale AM. Bioremediation of Waste Water from an Industrial Effluent System in Nigeria Using Pseudomonas aeruginosa: Effectiveness Tested on Albino Rats. J Pet Environ Biotechnol 2014;5(167).
6. Morales AR, Paniagua-Michel J. Bioremediation of Hexadecane and Diesel Oil is Enhanced by Photosynthetically Produced Marine Biosurfactants. J Bioremed Biodeg 2013;S4(5).
7. Khan F. In Silico Approach for the Bioremediation of Toxic Pollutants. J Phylogenetics Evol Biol 2013;4(161).
8. Chauhan A, Kaith B. Bioremediation of Natural Fiber by Graft Copolymerization. J Chem Eng Process Technol 2013;S6(2).
9. Makkar RS. Enzyme- Mediated Bioremediation of Organophosphates Using Stable Yeast Biocatalysts. J Bioremed Biodeg 2013;4(182).
10. Erkekoglu P, BelmaKoçer G. Testicular Dysgenesis Syndrome and Phthalates: Where do we Stand?. J Genit Syst Disor. 2015;4(1).
11. Tsompos C, Panoulis C, Toutouzas K, et al. The Effect of the Antioxidant Drug “U-74389g” On Endosalpingeal Edema during Ischemia Reperfusion Injury in Rats. J Genit Syst Disor. 2015;4(1).
12. Kumar P, Chhabra S. Rare Presentation of Haematometra and Haematocolpos Presenting as Bleeding Per Vagina. J Genit Syst Disor. 2015;4(1).
13. Lima-Silva J, Vieira-Baptista P, Beires J. Vulvar Abrikossoff’s Tumour: Case Report and Review of the Literature. J Genit Syst Disor. 2014;4(1).
14. Ventolini G. Vaginal Leptothrix: From Fungi to Lactobacillosis. J Genit Syst Disor. 2015;4(1).
15. Mahendru R, Bansal S. Leiomyoma through History: An Overview. J Genit Syst Disor. 2015;4(3).
16. Grau Piera S, Aguilo SO, Novell GM, et al. Clinical Manifestation, Diagnosis and Histology of Ovarian Luteoma: Case Report of Female Virilisation and Review of the Literature. J Genit Syst Disor 2015;4(4).
17. Goodman A, Joseph N, Bradford LS, et al. Global Health: Role of HPV Testing in Resource Poor Environment. J Genit Syst Disor. 2015;4(4).
18. Passarelli V, Gervasi MC, Aquila S. Recent Advances in the Human Male Gamete Molecular Composition in Normal and Varicocele Sperm and Steroid Receptors. J Genit Syst Disor. 2016;5(3).
19. Keller NA, Hall J, Sack V, et al. Maternal Congenital Central Hypoventilation Syndrome in Pregnancy: A Case Report. J Genit Syst Disor. 2016;5:3.

20. Gupta S, Sinha A. Potential Markers of Endometriosis: Latest Update. J Genit Syst Disor. 2016;5(3).
21. Bohbot JM, Druckmann R. Efficacy and Tolerance of a New Ointment in Non-Infectious Vulvitis, Anitis and Balanitis. J Genit Syst Disor. 2016;5(3).
22. Ni YY, Huang YW, Cao D, et al. Establishment of a DNA-launched infectious clone for a highly pneumovirulent strain of type 2 porcine reproductIVe and respiratory syndrome virus: identification and in vitro and in vivo characterization of a large spontaneous deletion in the nsp2 region. Virus Res. 2011;160(1).
23. Dayao D, Gibson JS, Blackall PJ, et al. Antimicrobial resistance genes in Actinobacillus pleuropneumoniae, Haemophilus parasuis and Pasteurella multocida isolated from Australian pigs. Aust Vet J. 2016;94(7).
24. Ward CK, Inzana TJ. Resistance of Actinobacillus pleuropneumoniae to bactericidal antibody and complement is mediated by capsular polysaccharide and blocking antibody specific for lipopolysaccharide. J Immunol. 1994;153(5).
25. Rioux S, Galarneau C, Harel J, et al. Isolation and characterization of a capsule-deficient mutant of Actinobacillus pleuropneumoniae serotype 1. Microb Pathog. 2000;28(5):279-89.
26. Bossé JT, Janson H, Sheehan BJ, et al. Actinobacillus pleuropneumoniae: pathobiology and pathogenesis of infection. Microbes Infect. 2002;4(2):225-35.
27. Jacques M. Role of lipo-oligosaccharides and lipopolysaccharides in bacterial adherence. Trends Microbiol. 1996;4(10):408-9.
28. Jacques M. Surface polysaccharides and iron-uptake systems of Actinobacillus pleuropneumoniae. Can J Vet Res. 2004;68(2):81-5.
29. Jacques M, Paradis SE. Adhesin-receptor interactions in Pasteurellaceae. FEMS Microbiol Rev. 1998;22(1):45-59.
30. Osicka R, Procházková K, Sulc M, et al. A novel "clip-and-link" activity of repeat in toxin (RTX) proteins from gram-negative pathogens. Covalent protein cross-linking by an Asp-Lys isopeptide bond upon calcium-dependent processing at an Asp-Pro bond. J Biol Chem. 2004;279(24):24944-56.
31. Sirois M, Lemire EG, Levesque RC. Construction of a DNA probe and detection of Actinobacillus pleuropneumoniae by using polymerase chain reaction. J Clin Microbiol. 1991;29(6):1183-7.
32. Ohshiro K, Kakuta T, Nikaidou N, et al. Molecular cloning and nucleotide sequencing of organophosphorus insecticide hydrolase gene from Arthrobacter sp. strain B-5. J Biosci Bioeng. 1999;87(4):531-4.
33. Gram T, Ahrens P. Improved diagnostic PCR assay for Actinobacillus pleuropneumoniae based on the nucleotide sequence of an outer membrane lipoprotein. J Clin Microbiol. 1998;36(2):443-8.
34. Dill KA. The meaning of hydrophobicity. Science. 1990;250(4978):297-8.
35. Abioye OP, Adefisan AE, Aransiola SA, et al. Biosorption of Chromium by Bacillus subtilis and Pseudomonas aeruginosa Isolated from Waste Dump Site. Expert Opin Environ Biol. 2015;4(1).
36. Ivanov VB, Alexandrova VV, Usmanov IY, et al. Comparative Evaluation of Migrating Anthropogenic Impurities in Ecosystems of the Middle Ob Region through Bioindication and Chemical Analysis. Vegetos. 2016;29(2).
37. Morsi MS, Farrag AA, Elewa AMT, et al. Environmental Impact of Anthropogenic Activities on the Surface Water Resource and Evaluated For Drinking and Domestic Uses around the River Nile, Assiut Governorate: Upper Egypt. J Hydrogeol Hydrol Eng. 2016;5(2).
38. Mahmud-Al-Rafat A, Mahbub-E-Sobhani, Taylor-Robinson AW. Understanding the Complex Relationship between the Human Pathogen Hantavirus and its Rodent Reservoirs Underpins a Rational Disease Control Strategy. J Virol Antivir Res. 2016;4(4).

39. Morsi MS, Farrag AA, Elewa AMT, et al. Quantitative Analyses of Surface Water and Groundwater Resources around the River Nile, Assiut Governorate, Upper Egypt: Water Quality in Relation to Anthropogenic Activities. J Hydrogeol Hydrol Eng. 2015;4(3).
40. Udaya Kumar P, Chandran A , Jose JJ, et al. Nutrient - Characteristics, Stoichiometry and Response Stimulus of Phytoplankton Biomass along the Southwest Coastal Waters of India. J Mar Biol Oceanogr. 2014;3(3).
41. Singh JS, Singh DP. Impact of Anthropogenic Disturbances on Methanotrophs Abundance in Dry Tropical Forest Ecosystems, India. Expert Opin Environ Biol. 2013;2(3).
42. Thelma J, Asha Devi NK. Evaluation of Probiotics from Mucus Associated Epibiotic Bacteria on Marine Fishes. J Mar Biol Oceanogr. 2016;5(3).
43. Sahu PK, Lavanya G, Gupta A, et al. Fluid Bed Dried Microbial Consortium for Enhanced Plant Growth: A Step towards Next Generation Bio Formulation. Vegetos. 2016;29(4).
44. Strehlow B, Bakowsky U, Pinnapireddy SR, et al. A Novel Microparticulate Formulation with Allicin In Situ Synthesis. J Pharm Drug Deliv Res. 2016;5(1).
45. Shikani AH, Jabra-Rizk MA, Shikani HJ, et al. Rhinotopic Therapy for Refractory Rhinosinusitis: Clinical Effectiveness and Impact on the Epithelial Membrane and Mucosal Biofilms. J Otol Rhinol. 2015;4(5).
46. Devi EC, Devi J, Kalita PP, et al. Phytochemical Analysis of Solanum virginianum and its Effect on Human Pathogenic Microbes with Special Emphasis on Salmonella typhi. J Forensic Toxicol Pharmacol. 2016;5(1).
47. Bošnjak M, Alfirevic Z, Alfirevic I, et al. Modelling Kinetics in Intestinal Compartment of Human Body as a Function of Applied Probiotics. J Food Nutr Disor. 2015;4(3).
48. Sene G, Thiao M, Mbaye MS, et al. The Linkages between Plant Species Composition and Soil Microbial Communities: What about Symbiotic Microorganisms within Man-Made Tree Plantations? J Biodivers Manage Forestry. 2014;3(4).
49. Debs-Louka E, El Zouki J, Dabboussi F. Assessment of the Microbiological Quality and Safety of Common Spices and Herbs Sold in Lebanon. J Food Nutr Disor. 2013;2(4).
50. Dimonte S, Babakir-Mina M. Variability and Signatures of Capsid Amino Acid of HIV-1 D-Subtype from Drug-Naïve and ARV-treated Individuals. J Virol Antivir Res. 2016;5(1).
51. Mandal S, Mandal MD. Can Bacteria Subsist on Antibiotics? J Forensic Toxicol Pharmacol. 2015;4(2).
52. Aslan A. Aquatic Microbiology in a Rapidly Changing World. Expert Opin Environ Biol. 2012;1(1).
53. Abioye OP, Adefisan AE, Aransiola SA, et al. Biosorption of Chromium by Bacillus subtilis and Pseudomonas aeruginosa Isolated from Waste Dump Site. Expert Opin Environ Biol. 2015;4(1).
54. Naddeo V, Scannapieco D, Belgiorno V. Membrane Technology in Wastewater Treatments. J Hydrogeol Hydrol Eng. 2012;1(1).
55. Thelma J, Asha Devi NK. Evaluation of Probiotics from Mucus Associated Epibiotic Bacteria on Marine Fishes. J Mar Biol Oceanogr 2016;5(3).
56. Prinzinger R, Misovic A, et al. Ontogeny of Blood Parameters in the Domestic Fowl Gallus gallus domesticus: II. Plasma Parameter. J Vet Sci Med Diagn 2015;4(5).
57. Prinzinger R, Misovic A, et al. Ontogeny of Blood Parameters in the Domestic Fowl Gallus gallus domesticus: I. Blood Cells and Haemoglobin. J Vet Sci Med Diagn 2015;4(5).

58. Roy SK, Maiti S, et al. Maternal Body-Mass-Index and Socioeconomic Factors Predict Gestational Duration and Birth Weight: A Cross-Sectional Study from India. Cell Biol: Res Ther 2015;4(1).
59. Hassanen RA, Morsy AA, et al. Leaf Dust Accumulation and Air Pollution Tolerance Indices of Three Plant Species Exposed to Urban Particulate Matter Pollution from a Fertilizer Factory. Vegetos 2016;29(3).
60. Heinrich J, Guo F, et al. Traffic-Related Air Pollution Exposure and Asthma, Hayfever, and Allergic Sensitisation in Birth Cohorts: A Systematic Review and Meta-Analysis. Geoinfor Geostat: An Overview 2016;4(4).
61. Chaube R, Pandey AK, et al. Pentachlorophenol-Induced Oocyte Maturation in Catfish Heteropneustes Fossils: An In Vitro Study Correlating with Changes in Steroid Profiles. J Pharm Sci Emerg Drugs 2016;4(1).
62. Bhupander Kumar, Virendra Kumar V, et al. Human Health Hazard due to Metal Uptake via Fish Consumption from Coastal and Fresh Water Waters in Eastern India Along the Bay of Bengal. J Mar Biol Oceanogr 2013;2(3).
63. Feng H, Nwachukwu MA. Should Dispersants be Used to Alleviate the Impact of a Marine Oil Spill? J Hydrogeol Hydrol Eng 2012;1(1).
64. Dimonte S, Babakir-Mina M. Variability and Signatures of Capsid Amino Acid of HIV-1 D-Subtype from Drug-Naïve and ARV-treated Individuals. J Virol Antivir Res 2016;5(1).
65. Mandal S, Mandal MD. Can Bacteria Subsist on Antibiotics? J Forensic Toxicol Pharmacol. 2015;4(2).
66. Aslan A. Aquatic Microbiology in a Rapidly Changing World. Expert Opin Environ Biol 2012;1(1).
67. Ukpaka CP. Modelling the Methodology for Crude Oil Bioremediation Decision Tree for an Integrated Environmental Management System. J Chem Eng Process Technol 2017;8(325).
68. Ritu A, Anjali C, et al. Biopesticidal Formulation of Beauveria Bassiana Effective against Larvae of Helicoverpa Armigera. J Biofertil Biopestici 2012;3(120).
69. Ukpaka CP, Kingdom U. Effect of Physicochemical Parameters on Screening Characteristics of Suspension in Bioremediation Sampling. J Anal Bioanal Tech 2017;8(345).
70. Meliani A, Bensoltane A. Biofilm-Mediated Heavy Metals Bioremediation in PGPR Pseudomonas. J Bioremediat Biodegrad 2016;7(370).
71. Aulwar U, Awasthi RS. Production of Biosurfactant and their Role in Bioremediation. J Ecosys Ecograph 2016;6(202).
72. Pisciotta JM, Dolceamore JJ. Bioelectrochemical and Conventional Bioremediation of Environmental Pollutants. J Microb Biochem Technol 2016;8.
73. Akpomie Olubunmi O, Ejechi Bernard O. Bioremediation of Soil Contaminated with Tannery Effluent by Combined Treatment with Cow Dung and Microorganisms Isolated from Tannery Effluent. J Bioremed Biodeg 2016;7(354).
74. Satyapal GK, Rani S, et al. Potential Role of Arsenic Resistant Bacteria in Bioremediation: Current Status and Future Prospects. J Microb Biochem Technol 2016;8(256).
75. Azoddein AABM, Ahmad MM, et al. A Bioremediation Approach to Mercury Removal in a Shake Flask Culture Using Pseudomonas putida (ATCC 49128). J Anal Bioanal Tech 2016;7(312).
76. Ramakrishnan B. Bioremediation with Simultaneous Recovery and Reuse of Resources. J Bioremed Biodeg 2016;7(e172).
77. Uqab B, Mudasir S, et al. Review on Bioremediation of Pesticides. J Bioremed Biodeg 2016;7(343).

78. Xenia ME, Refugio RV. Microorganisms Metabolism during Bioremediation of Oil Contaminated Soils. J Bioremed Biodeg 2016;7(340).
79. Kiraye M, John W, et al. Bioremediation Rate of Total Petroleum Hydrocarbons from Contaminated Water by Pseudomonas aeruginosa Case Study: Lake Albert, Uganda. J Bioremed Biodeg 2016;7(335).
80. Uqab B, Mudasir S, et al. Bioremediation: A Management Tool. J Bioremed Biodeg 2016;7(331).
81. Jesus HE, Peixoto RS, et al. Bioremediation in Antarctic Soils. J Pet Environ Biotechnol 2015;6(248).
82. Obreque-Contreras J, Pérez-Flores D, et al. Acid Mine Drainage in Chile: An Opportunity to Apply Bioremediation Technology. Hydrol Current Res 2015;6(215).
83. Luisa WM, Letícia T, et al. Culture-Independent Analysis of Bacterial Diversity during Bioremediation of Soil Contaminated with a Diesel-Biodiesel Blend (B10)S. J Bioremed Biodeg 2015;6(318).
84. Caruso G. Plastic Degrading Microorganisms as a Tool for Bioremediation of Plastic Contamination in Aquatic Environments. J Pollut Eff Cont 2015;3(e112).
85. Hamid B, Kaushik G, et al. Isolation and Development of Efficient Bacterial Consortia for Bioremediation of Textile Dye Effluent. J Pollut Eff Cont 2015;3:142.
86. Sadiq S, Inam HM, et al. Bioremediation Potential of White Rot Fungi, Pleurotus Spp against Organochlorines. J Bioremed Biodeg 2015;6(308).
87. Nandi R, Mukherjee K, et al. Surfactant Assistant Enhancement of Bioremediation Rate for Hexavalent Chromium by Water Algae. Biochem Physiol 2015;4(173).
88. Soumya GN, Manickavasagam N, et al. Optimization of pH, Retention Time, Biomass Dosage in Beads and Beads Density on Textile Dye Effluent Bioremediation using Seagrass, Cymodocea rotundata Beads. J Bioremed Biodeg 2015;6(295).
89. Mukherjee P. Bioremediation with the Help of Analytical Tool- Biosensors. J Bioremed Biodeg 2015;6(292).
90. Pawar RM. The Effect of Soil pH on Bioremediation of Polycyclic Aromatic Hydrocarbons (PAHS). J Bioremed Biodeg 2015;6(291).
91. Iturbe R, López J. Bioremediation for a Soil Contaminated with Hydrocarbons. J Pet Environ Biotechnol 2015;6(208).
92. Kumar R, Chauhan A, et al. Bioremediation of Polluted Soil obtained from Tarai Bhavan Region of Uttrakhand, India. J Bioremed Biodeg 2015;6(276).
93. Kulkarni AG, Kaliwal BB. Bioremediation of Methomyl by Soil Isolate - Pseudomonas aeruginosa. J Bioremed Biodeg 2015;6(281).
94. Paniagua-Michel J, Rosales A. Marine Bioremediation- A Sustainable Biotechnology of Petroleum Hydrocarbons Biodegradation in Coastal and Marine Environments. J Bioremed Biodeg 2015;6(273).
95. Ofoegbu RU, Momoh YOL, et al. Bioremediation of Crude Oil Contaminated Soil Using Organic and Inorganic Fertilizers. J Pet Environ Biotechnol 2015;6(198).
96. Shah MP. Environmental Bioremediation: A Low Cost Nature's Natural Biotechnology for Environmental Clean-up. J Pet Environ Biotechnol 2014;5(191).
97. Saraswat S. Patent Analysis on Bioremediation of Environmental Pollutants. J Bioremed Biodeg 2014;5(251).
98. Garima T, Singh SP. Application of Bioremediation on Solid Waste Management: A Review. J Bioremed Biodeg 2014;5(248).

99. Gularte HF, Diaz ME, et al. Effect of Temperature and Salts on Phenol Bio-Availability in Polluted-Sandy- Soils: A Practical Biotechnological Approach before Microbial Bioremediation. J Bioremed Biodeg 2014;5(240).
100. Sabale SR. Contamination and Need of Bioremediation of Pesticide Residues in Fresh Water Aquifers. J Bioremed Biodeg 2014;5(e158).
101. El-Bestawy E, Sabir J, et al. Comparison among the Efficiency of Different Bioremediation Technologies of Atrazine–Contaminated Soils. J Bioremed Biodeg 2015;5(237).
102. Hasan R, Zhang B, et al. Bioremediation of Swine Wastewater and Biofuel Potential by using Chlorella vulgaris, Chlamydomonas reinhardtii, and Chlamydomonas debaryana. J Pet Environ Biotechnol 2014;5(175).
103. Malik A. Hazardous Cocktails: Challenges and Innovations in Bioremediation. J Bioremed Biodeg 2014;5(e156).
104. Kulshreshtha S, Sharma K. Perspectives of Bioremediation through Mushroom Cultivation. J Bioremed Biodeg 2014;5(e154).