Embassy of Italy in New Delhi

TECO

TECHNOLOGICAL ECO-INNOVATIONS FOR THE QUALITY CONTROL AND THE DECONTAMINATION OF POLLUTED WATERS AND SOILS

FIRST NETWORKING CONFERENCE

NEW DELHI, 16 AND 17 NOVEMBER 2016

GULMOHAR HALL, INDIA HABITAT CENTRE

PROCEEDINGS

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Photos by Serena Carloni

INTRODUCTION

TECO project is a powerful tool to strengthen the cooperation between EU and India through the participation of different actors in the field of the environmental sustainability, ranging from Scientific Institutions to Private Companies passing through target groups and stakeholders. TECO project is offering a real possibility to share common experiences and solutions and to improve skills and expertise in order to create an innovative approach to the dramatically actual topic of the decontamination of soils and water.

In this frame, the first TECO Networking Conference represents a significant event to gather and discuss the outcomes of the project so far and an opportunity for all the participants to open up towards new collaborations and to reinforce the current partnerships.

I will devote all my efforts in the next years to meet the challenges and to make TECO a successful way to create a partnership of highly qualified experts to face these environmental problems through sustainable and eco-innovative technologies.

I wish all the participants to have a fruitful meeting.

Massimo Zacchini

TECO Project Coordinator Italian Side, CNR-IBAF

It gives me immense pleasure to welcome the delegates to the Networking conference of the EU cosupported project “Techno eco Innovations for the quality control and decontamination of polluted waters and Soil”.

The project has given opportunity to many researchers in India to host EU researchers who are keen to work in the theme areas of the TECO project.

As we complete two years of the project and look forward to hosting the networking conference, researchers from EU and India have evinced lot of interest for collaboration. The mobility of the EU researchers to different Institutes in India has been steady under the umbrella of the TECO project. We look forward to strengthening of the mobility and collaboration over the next two years for the success of the project.

I look forward to a successful networking conference.

Paras R. Pujari

TECO Project Coordinator Indian Side, CSIR-NEERI

FOREWORD

It's impossible to talk about India without talking about water and about the role that this natural resource has always had in the history of this country. Indian religions and cultures are full of symbols, deities, rituals and stories linked to water which is always seen as something sacred and capable to bring health and peace, being the country enriched with sacred ponds and holy rivers. And water is also one of the main worries of a country which accounts for more than 17% of the total world population and is geographically so complex that it has to manage during the year both severe droughts and sudden floods and has often to make courageous choices which are complex and delicate. Issues like the wise exploitation of groundwater resources for freshwater supply and the sustainable use of streams and rivers for hydroelectric power generation and irrigation are only some of the many possible examples. At an higher strategic level, water quality is also one of the key issues for a country which is facing all the advantages and the problems of a quickly developing economy in a hugely populated, federal and multicultural context. The impressive industrial development of India has also become faster during the last few years and has also affected the land use, producing contaminations due to the disposal of wastes and an indiscriminate usage of chemicals in daily life and agriculture.

I really believe in a productive and long lasting collaboration between Italian, European and Indian scientists in these field of studies where the practical aspects of preservation and restoration of environmental quality needs to be feed with new ideas, fresh technologies and a close cooperative work.

India, Italy and Europe, due to their ancient cultural roots, certainly can share a deep feeling of belonging to the land and an approach where the management of the natural resources necessarily takes also into consideration the involvement of deep spiritual and emotional aspects.

For all these reasons the Embassy of Italy is enthusiastically giving full support to this initiative in the belief that this event, linked to the TECO project, can represent the ideal meeting point for launching future scientific interactions and steady collaborations.

Massimo Spadoni

Scientific Attaché Embassy of Italy in New Delhi

TABLE OF CONTENTS

SENSING TECHNOLOGY SESSION

OTHER CONTRIBUTIONS

INAUGURATION OF INDO-ITALIAN RESEARCH HUB

Indo-Italian Research: an Hub to take off

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The Indo-Italian collaboration in science and technology has a long lasting tradition. The first bilateral agreement between the Governments of the two countries was signed in 1978. The "*Italian National Research Council (CNR)*" has a very active scientific collaboration with "*Council of Scientific and Industrial Research (CSIR)*" since 1995, operating through periodic (three years based) calls for proposals. There are five projects funded under the CNR-CSIR Bilateral Scientific and Technological Cooperation Programme 2016-2018 and the scientific coordinators of two of them will attend this TECO Networking Conference. India has important scientific collaborations with other actors of the Italian research, as Universities and Research Centres, while a closer cooperation in research and innovation is also emerging between India and the European Union.

Indian scientific outcomes, such as those in space and nuclear technology, pharma research, IT, telecommunications and biotechnologies, have significantly contributed to the acknowledgement of this country as one of the most important players of the global economy. In the last decade Indian public investment in R&D has grown sensitively, and the number of Indian scientific publications increased more than 12% per year, against the global average of 4%.

In this framework, when considering central role of internet and World Wide Web to connect people and spread updated information, we stepped forward from the positive experience of the informal group of Indo-Italian scientists gathered with the name of "*Indo-Italian Centre of Excellence for Environmental Sustainability*" unofficially established after a workshop between CSIR-NEERI and CNR in 2013, and we decided to launch a website with the purpose to store and share all the most important results of the Indo-Italian cooperation in S&T. We are showing in this conference the main structure and the potential of this tool which also aims to share and stimulate new research ideas, to create new contacts and collaborations, to find financial resources with the involvment of the private sector and, more in general, to spread accurate information on the ongoing and past activities.

As Archimedes of Syracuse, one of the most popular and great scientist of the ancient history, used to say "*Give me a lever long enough and a fulcrum on which to place it, and I shall move the world*", similarly we believe that TECO Project and this web site could be a good "lever" and "fulcrum" to inject the Indo-Italian research with new energy and to foster a brighter future made of more and more productive collaborations.

Acknoledgments: *The Embassy of Italy in New Delhi is deeply thanked for the financial support.*

TECO SESSION

One year of TECO mobility grants

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Keywords: mobility, networking Europe-India, new collaborations.

In 2016, the TECO Project assigned a total of 16 months of mobility grants towards India, finalized to the opening of new professional collaborations and to the implementation of thematic networks in the field of water and soil quality. In this frame, TECO supported 13 exchange projects between research centres, private industries, SMEs and public institutions, giving the opportunity to share experiences and start-up collaborations in India.

TECO has received submissions from Germany, France, Slovakia, Sweden, Italy and Spain; the beneficiaries of the grants belongs mostly to public Institutions (Universities and National Research Institutes); 3 of them comes from the private sector; all of the applicants have chosen a Public Research Centre as Indian hosting Institution. Among the approved projects, the covered subjects are very various; even if all of them are related to water and soil quality, they range from geology, to biology, to filmmaking.

For the next year, drawing from the positive experience of 2016, we aim to further disseminate the TECO mobility opportunities, by widening the invitation for TECO mobility programme to master students and private companies. All the mobility projects carried on during 2016 will be presented during this first Networking Conference of TECO Project, looking forward to increase the networking and to involve new hosting institutions in India.

Silicon application and phytomerediation may help in environmental restoration of polluted soils

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Keywords: abiotic stress, phytoremediation, silicon in agriculture.

Soil pollution is one of the serious problems worldwide. Toxic substances from soils polluted by industry, agriculture and waste waters enter the food chain via plants and accumulate in human bodies causing various health problems. The situation in some areas of the world is alarming.

Several measures can be adopted to improve the environmental restoration. Besides costly and difficult direct chemical or technical treatment of polluted soils, other more environmental friendly ways are possible. Among them is the use of substances increasing resistance of plants to abiotic stress. Silicon was identified as an element alleviating abiotic (also biotic) stress in several plant species [1-2]. International society focused on research of silicon role in agriculture was recently established [http://www.issag.org/]. Plants can be used also for phytoremediation of polluted soils. Special hyperaccumulating species or fast growing plants with high biomass production can be employed. Examples of suitable species with focus on intraspecific variability and results with silicon application will be discussed [1-4]. Important for the healthy food production is limited accumulation of toxic substances in the edible parts of crops, or consumed parts of fetter. For this barriers of transport pathways in plant bodies are crucial [5]. Each site and geographical region requires different way of phytoremediation. Screening, selection, identification, characteristic and application of suitable plant species require intensive research and collaboration of specialists from various areas of plant biology, chemistry, soil sciences and biotechnology.

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Effect of PM10 chemical components on mRNA stability and processing

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Keywords: air pollution PM10, mRNA, miRNA, exposome.

The air pollution is a global threat for ecosystems and, as consequence, for human health. The atmospheric contamination can have an impact on biological system, primarily humans, through two different routes: by direct inhalation of pollutant mixture; by food or water contaminate by atmospheric events (rain, snow, wind). The synergistic action of two exposure ways contributes to the overall stress. Integrated approaches combining molecular biology epidemiological and socio-economic information have allowed to face the problem of long term exposure in a more comprehensive way. This relative new approach, called 'exposome' [1], is focused on the deep investigation of effect of multiple pollution sources on the individual health. In the last decade NGS techniques, including RNA-seq [2], have turned up the role on RNAs on the response against environmental, biological or chemical-physics stress factors. In term of environmental toxicology the effects on translational and RNA degradation processes can occur even in the case of low level of exposure applied for long time. Among contaminants that could impact the functionality of different RNAs, the particulate matter actually are probably those actually are the widely studied. In a previous paper we have considered the interaction between pollutants and ncRNAs [3]. Here we analysed the potential interaction of PM10 chemical components on RNA regulatory elements (Poly-A site, AU-rich and m6A) located in the 3'utr of target genes. The initial data were obtained from an environmental and epidemiological survey in Koradi (Maharashtra) area. This analysis suggests that organic compound can influence the mRNA processing pathway altering the protein-nucleic acid recognition.

***Acknowledgements**: This research was supported by TECO project.*

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Impact of pyrometallurgical slags on sunflower growth, metal accumulation and rhizosphere microbial communities

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Keywords: heavy metals, microbial diversity, pyrometallurgical slags, rhizosphere, sunflower.

Metallurgical exploitation originates metal-rich by-products, which are often disposed in the environment being a source of anthropogenic heavy metal pollution [1]. Despite the environmental risk that this may pose for living organisms, little is known about the impact of slags on biotic components of the ecosystem like plants and rhizosphere microbial communities [2].

The present research aimed to study the effects of metal-rich pyrometallurgical slags on plant growth, metal accumulation and soil microbial diversity. A pot experiment was conducted using as growing substrate for sunflower (*Helianthus annus*) a mix (50% w/w) of an agricultural soil and metal-rich (Cu, Pb, Zn) slag. After 90 days plants were harvested to determine biometric parameters and to quantify metals in plant tissues. The content of metals in bioavailable soil fractions and a leaching test in the presence of soil solution were also performed. Finally, microbial diversity was assessed by using 16S rRNA gene based denaturing gradient gel electrophoresis (DGGE) and community level physiological profiling (CLPP) analyses.

The results showed that sunflower was able to grow in the presence of slags accumulating Cu, Pb and Zn in roots, shoots and flowers. Bioavailability of metals was, in increasing order: Pb<Cu<Zn. Low leaching levels of metals from slags in the presence of soil solution were observed. The study of rhizosphere microbial diversity is still in progress, and preliminary results indicate a microbial community shift induced by slags.

Implications from this study are expected to contribute to the development of sustainable practices for the management of pyrometallurgical slags.

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Sacred Waters, Polluted Sins

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Keywords: Ganges, sacredness, pollution, human behaviour, Tagore.

The Ganges is India's holiest river, considered a source of spiritual purification. But today the river is among the world's most polluted, struggling under the pressures of modern India. People believe Ganga can take care of their sins, and they forget that while Ganga can take care of sins it cannot take care of the waste, of their pollution. Tough pollution laws and water treatment plants may be able to clean up the pollution in these rivers. Countless nonprofits, activists and environmental groups are working to make sure these words actually become action. Because if India can clean up one of the dirtiest rivers in the world, who knows what else this great rising nation can achieve?
This project aims to witness the evolution of the government's project "Clean Ganga" reporting small and great stories to understand how a "scientific" awareness of the sacredness of the rivers can help to modify wrong habits and policies. A story that will have like a guide the poet and philosopher Rabindranth Tagore. Perhaps like the great Sage Gautama said: "It's time for us all to pray for our sin - our sin of allowing these rivers to become so threatened. Maybe the gods will hear our prayers and fill the rivers with fresh, clean water so that we can purify ourselves again".

CHALLENGE SESSION

Challenges for technology transfer from the research to the market

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Keywords: phytotechnologies, spin-off, remediation technologies (Arial 11 pt)

Knowledge produced in long-term studies and researches on plant and environment interactions has been transferred into a sustainable technology to use for coping with various environmental criticalities. Plant biodiversity resources and functions have been analysed from the literature on results of phytoremediation experiments and organized in a searchable database for identifying candidate plants for removal/containment of moderate concentrations of contaminants from soils and waters. A suitable plantation system based on selected plants among candidate able to establish on soils at very high density (1 plant per m^2) is a co-essential core of this (phyto) technology. Three experimental applications in national interest sites of Italy, contaminated the first with heavy metals (Cd, Zn, Pb and As) and the other two with hexachlorocyclohexane isomers (HCH) and polichlorobiphenils (PCB) congeners, have been evaluated respectively for removal/containment and for degradation to validate the set up remediation technology. The promising results have motivated the constitution of a spin off company aimed to transfer into the market this technology, in partnership with an enterprise already consolidated in soil remediation with traditional technologies.

Low Cost Technological Solution for Water Quality Improvement in Eastern Uttar Pradesh in India: *A Proposal for joint Research between ENEA, Italy and MMMUT, Gorakhpur*

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Water, a life sustaining component of the planet is reeling through acute stress due to its quality degradation due to various adversities faced by environment and ecology. Projections indicate that in spite of India receiving an annual precipitation of about 4000 km^3, it would be under water stressed country by 2025. Amongst various reasons for the probable water crisis, the growing population and improving living standards is significantly responsible for it. With more extravagant and rampant development, contamination of water resources: surface water and ground water, from point and non-point sources is growing at a fast pace. Therefore, there is critical need to address and resolve the major issues through innovative methods and technologies.

Generally, the water reaching lower layers of soil and the salts dissolved in water come to the top soil through capillary action and pollute the soil as well. Such soils with high concentrations of salts turn into sodic wastelands, unfit for agricultural production. The dependency of people of late on groundwater for drinking and other domestic purposes has increased significantly due to the limited availability of surface water and that too being polluted. This poses a major health risks to people who do not have access to treated water. Thus, it can be judiciously inferred that the challenge to keep water and soil healthy at this conjecture is a bigger task and should be handled in a phased manner with integrating cities, states and country.

Gorakhpur located along the banks of Rapti river in the eastern part of the Indian state of Uttar Pradesh suffers under same grave situation of water quality degradation. Gorakhpur lying in tarai area of trans-Saryu region and due to frequent meandering of the river Rapti in the past, the topography of the city and nearby region is badly affected. Ground water is the only source of drinking water in the city. This place though has an advantage in terms of high ground water table but has got contaminated. As per the Jal Nigam, U.P. report, the first two layers of the ground water are totally contaminated. Industrial effluents are not only deteriorating the river quality but it is also affecting the groundwater of its adjoining areas because of river pollution. The BOD, COD, DO and acidity were not mentioned in Indian drinking water standards but still it is reported positively (BOD: 8-45 mg/l, COD: 21 – 109.2 mg/l, DO: 2.5 – 9.4 mg/l) in year 2012.

The extraction of this groundwater, by own electric driven bore well or hand pumps, low levels of literacy and awareness, and economic conditions exposes them to serious threats of groundwater contamination. Water extracted from these shallow wells generate health problems and create bacterial and gastro-intestinal disorders in a large scale among population. In summer season, these problems become very chronic due the water table going low due to drought. This grave situation has severely affected the poor and vulnerable people who do not have any options but to suffer from these. With discharging of waste from industrial and urban effluents along with waste water irrigation contributes significant percentage of

heavy metals in soils. Other sources include usage of fertilizer and pesticides. The contamination of soils directly influences public health, because soils exert a direct impact on human health, potentially toxic to crops, animals, and humans.

Seeing the present scenario in terms of water availability and water quality along with soil contamination for Gorakhpur and nearby region, it could be inferred that the issue is very serious. No availability of surface water source which can serve as an intake for water distribution. The highly polluted regime of Ami river polluting the groundwater. High dependency on groundwater for dwelling purposes which in turn is polluted poses greater health risks to life of residents of Gorakhpur and nearby eastern region of Uttar Pradesh.

Thus, there is an urgent need to monitor surface water sources and groundwater quality, devising economical technological solutions to decontaminate groundwater and revive the vast stretches of surface water which are so polluted with organic load that the aquatic life has failed to exist thus disrupting the ecosystems of river along with river health in the interest of the residents with poor economic conditions in the region.

Addressing issues related to geogenic contaminants in Punjab, India: Solution Conundrum

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Keywords : geogenic contaminants, water treatment, water solution conundrum.

When over 2 billion people gained access to improved water sources, the UN proclaimed the Millennium Development Goal related to providing access to water as being met (UNICEF & WHO, 2012) irrespective of source reliability and contamination. Today, 90% of India's rural population has access to an improved water source[1]; however, much of this success is based on groundwater sources often containing geogenic contaminants like fluoride, arsenic, nitrate, uranium, and elevated levels of total dissolved solids (TDS). In Punjab, the problem of geogenic contaminants is coupled with rapidly declining water tables. Many point to Punjab as the epicenter of the green revolution; however, what has been less well documented is the rapid rate at which groundwater reserves and water quality have diminished in the area over the last few decades (Russo, Lall, & Vatta, 2009).

Several solutions for providing safe water to 4000 quality affected habitations are attempted by the concerned authorities in Punjab which range from supplying water from surface sources and using technologies such as reverse osmosis. However, authorities are facing solution conundrum to optimally design projects for supplying safe water in these affected habitations. This presentation would include extent of geogenic contamination, health effects, depletion of ground water, current technological solutions adopted for safe water supply and limitations and possible solutions. Effective social integration of technology, designing/selecting technology to best meet the needs, evaluating the social aspects of the technology integration, and strengthening operation and monitoring of technological interventions appear to be the way forward in Punjab.

Acknowledgements*: Department of Water Supply and Sanitation, Government of Punjab; Ministry of Drinking Water and Sanitation, Government of India; Director, CSIR-NEERI, TECO Conference Organisers.*

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Restoring Degraded Lands in India: Challenges and Perspective

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Keywords: Land Degradation, Restoration, Bioremediation, Biofuels

With merely 2.5% of the world geographical area, India support about 18% of the world's human and 20% of the livestock population. The growing demand for food, fodder, biomass and biofuel production impose severe pressure on limited land resources. Likewise in the case of other developing countries, there is ever increasing competition for arable land in India for uses in agriculture and other developmental activities. It has been estimated that about 36% land of the total Indian geographical area is degraded due to unsustainable agricultural practices, deforestation, urbanisation, industrialisation and land and wind erosion [1-2]. Moreover, there is a growing concern that the changing climatic condition will significantly affect the soil quality and biodiversity. Therefore, decreasing biological or productive capacity of land system poses a serious threat to agricultural, food and environmental sustainability. Unfortunately, there is a paucity of information regarding the multiple drivers of land degradation in India and there is no national level efforts to monitor the extent of land degradation and developing sustainable strategies for managing such degraded lands for multipurpose environmental benefits. Importantly, there is no bench marks to assess the performance of restoration activities. Therefore, the present discourse is intended to provide state-of-the-art information on extent of land degradation in India and recommend sustainable strategies for revitalizing such degraded system for multipurpose environmental benefits like soil carbon sequestration and deriving biomass, biofuel and other bioproducts for supporting a biobased economy [3].

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Management of Contaminated Sites in Europe

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Keywords: contaminated site, Europe, soil remediation.

The aim of this report is to present the current state of knowledge about the management and regulation of contaminated sites in Europe with a special focus on Italy.
The large volumes of waste produced in Europe and the use of chemicals in recent decades have resulted in the contamination of soil and water. The overall European policy objective is to prevent the potential risk to the environment and to human health caused by contaminants and to prevent new contamination.
There are about 2.5 million potentially contaminated sites in Europe. In these sites it is suspected the contamination and are necessary detailed surveys; 115,000 of these sites are already recognized as contaminated, almost half of them (46%) have already been reclaimed; 28 out of 39 Countries say they keep inventory of contaminated sites.
Mining activities, metallurgical industries and gas stations are the most frequent sources of soil and groundwater contamination. The main polluting activities varies greatly from Country to Country; the distribution of various contaminants is similar to the solid and liquid matrix; the most common contaminants are heavy metals and mineral oils.
Information presented are mainly extracted from a guide of the European Commission published in 2014 by the Institute for Environment and Sustainability - Joint Research Centre.

REMEDIATION TECHNOLOGY SESSION

Approach to Remediation of Contaminated Sites

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Key Words: waste, contamination, mechanism, remediation, remediation protocol.

Contaminated site is referred to a land or site that is unfit for agricultural or any domestic human activities or does not support or disturbs the local ecology. Of course, there can be other definitions as well. The contamination is usually caused by uncontrolled and unscientific waste disposal, especially chemical wastes. Contamination of a land or any natural resource is caused by certain mechanisms which are based on the some simple physical and chemical phenomena like adsorption, absorption etc.. Remediation is referred to the treatment that 'permanently and significantly reduces the volume, toxicity, or mobility of hazardous substances, pollutants and contaminants as a principal element'. Usually contamination is caused by a particular chemical/s in the waste and not by entire waste matrix. However, entire contaminated resource has to be subjected to the remediation. Further, extent of contamination may increase due to migration of the chemical in the natural resource. Therefore, identification of the contaminant/s and extent of contamination are the principal steps in the remediation protocol. Treatability studies and decision on selection of remediation method comes next. Based on the site conditions, remediation methodology is decided and finally implemented to achieve the desired or targeted remediation levels. The presentation deals with all these aspects of remediation and discusses a case study in brief.

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Photodynamic inactivation for water treatment: a sustainable method towards clean water

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Keywords: water disinfection, photoinactivation, photosensitizers, singlet oxygen, visible light.

The unwanted spread of pathogenic microorganisms in the environment due to natural or human action poses a serious threat to human and animal health. These microorganisms are capable of multiplying in air, water and soil endangering the ecological balance. In particular contaminated water is responsible for millions of deaths worldwide every year [1]. Many developed countries have succeeded in providing clean water for domestic use but obtaining clean, microbe-free water in several developing and under developed nations remain a challenge.

Conventional methods of water disinfection like chlorination and other chemical methods are no doubt effective but these methods have side effects of producing harmful by products and also become hazardous when the dosage exceeds the allowed limit. Hence, new effective and low cost methods of water purification must be developed for better sustainability. Moreover, microbial strains developing resistance towards disinfecting agents also calls for alternative disinfection techniques. Photocatalytic disinfection is one such method that is gaining interest as it involves three individually harmless components viz. photosentizer, light and molecular oxygen [2]. Some organic and inorganic catalyst on light irradiation in presence of oxygen produce reactive oxygen species (ROS) like singlet oxygen, hydroxyl radical (superoxide anion) that are cytotoxic species and are capable of killing bacteria, fungi and viruses [3-5]. The present discussion includes the basic principles involved in photodynamic inactivation. We have synthesized different photoactive materials like porphyrin and related compounds. The photosensitizers are also immobilized on solid supports like magnetic nanoparticles and polymers. The photodisinfection efficiency of these materials are highlighted.

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Improved safe management of arsenic-rich waste generated from arsenic removal plant

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Keywords: arsenic, drinking water treatment, waste disposal.

In the last decades, different countries experienced the problem of high As concentration in water intended for human consumption. Centralized and decentralized treatment have been proposed and adsorption onto iron oxy-hydroxides resulted the most convenient solution [1]. The management As-rich exhausted filters has received still little attention [2]. Solid As concentration in Fe sludge varies greatly (1-80,000 mg/kg). New frontiers in As-treatment technologies tend to commercialize filters with increasing adsorption capacity (>50 mg_{As}/g_{Fe}). Therefore, there is a strong demand for development of environmentally safe and effective disposal methods for arsenic contaminated sludge out of water treatment system [3].
In Italy, waste produced by water treatment are classified as not hazardous and disposed according to EU Directive 99/31/EC. They can be directly disposed in landfill if As <200 µg/L in the leachate. Evaluation of As-sludge leaching potential is usually performed only using chemical leaching procedures (TCLP and WET). In landfill conditions, key parameters to properly assess leaching behaviour are solution properties, test duration, experimental headspace and biotic processes [3].
While landfills are commonly used for sludge disposal in Europe, in India rapid urbanization has made it increasingly difficult to find suitable landfill sites. Often, As-rich wastes are disposed of nearby rivers or low laying areas, which is likely to pollute surface and groundwater. There is need to find more environmental friendly sludge disposal solutions for a long-term strategy. A possible feasible solution to reduce landfill or even improper disposal appears to be recycling of the sludge and use it for beneficial purposes [4-5].

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In situ chemical oxidation (ISCO) technology for remediation of pesticide contaminated soil and groundwater

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Keywords: *in situ* chemical oxidation (ISCO), organic contaminants, pesticides, soil and groundwater.

Remediation of pesticide contamination is of significant interest at both manufacturing and application sites due to their toxicity and regulatory limits in water and soil. Organochlorine pesticides are the important group of pesticides concern due to their persistent nature and adverse effect on natural environment and human health.

In situ chemical oxidation (ISCO) is a viable technology used to remediate pesticide contaminated soil and groundwater systems, which utilize chemical agents (i.e. active chemical oxidants) are capable of oxidizing organic contaminants [1-2]. The most common oxidants in the ISCO processes are catalysed H_2O_2 propagations (i.e. modified Fenton's reagent), permanganate, and activated persulfate [3-4]. Persulfate is an increasingly popular ISCO reagent because it is significantly more stable than hydrogen peroxide, providing the potential for transport from the point of injection to contaminants in lower permeability regions of the subsurface.

The effectiveness of oxidation process depends upon the geological conditions, the residence time of the oxidant, the amount of oxidant used and the effective contact between oxidant and the contaminants. Though ISCO offers several advantages over other *in situ* or *ex situ* remediation technologies which also have some limitations. Field tests have proven that ISCO is a sustainable remediation technology for contaminant reduction in source areas as well as for environment renewal. The application of chemical oxidation methods not only for remediation of contaminated sites but also for simulation of the biodegradation process is an exceedingly perspective modern way of successful remediation of environment.

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Hexavalent Chromium Remediation using Reducing Agents - Case Study

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Keywords: remediation, site characterization, hexavalant chromium, chemical reduction, calcium polysulphide.

This abstract presents a case study for one of the first projects in India which demonstrated chemical reduction of Hexavalant chromium (Cr VI) to Trivalant Chromium (Cr III) in the field. *In-situ* and *Ex-situ* techniques were tested in the field to determine the effectiveness. Different reductants such as glucose and Calcium Polysulphide (CPS) were tested in combination to evaluate the effectiveness. This project assumes significance in light of the current regulatory trends in India, such as development of National Programme for Rehabilitation of Polluted Sites where a several chromium sites were included.

The project was conducted under Capacity Building for Industrial Pollution Management Project (CBIPMP) funded by the World Bank for West Bengal Pollution Control Board (WBPCB). The Site include orphan land (public & private) in the eastern part of India where chromium bearing sludge was dumped (over 30+ years) along a highway by some industries (no longer in operation).

ERM conducted laboratory treatability test and field pilot study. Laboratory treatability test (171 reactors) includes glucose and CPS individually and in combination to find the optimum dosage rate. Test condition of glucose followed by CPS treated all 27 samples to remediation goal of <50 milligram per kilogram (mg/kg). The field demonstration included *In-situ* and *Ex-situ* techniques. The results indicated that more than 99% removal rates can be achieved by chemical reduction of Hexavalant chromium (Cr VI) to Trivalant Chromium (Cr III).

Voluntary Remedy of Chlorinated Hydrocarbon Impacted Soil and Groundwater

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Keywords: remediation, site characterization, volatile organic compound, soil vapor extraction, Pump and Treat.

This abstract presents a case study for one of the first remediation projects in India using conventional in-situ and ex-situ technologies starting in mid-2000's. Upon discovering chlorinated volatile organic compound (CVOC) impacts in Site soil and groundwater, the business initiated site investigations and notified the state regulatory authority. Remediation was carried out voluntarily per the international standards including transparent stakeholder engagement. High resolution site characterization techniques, pilot testing, statistical data analysis and groundwater modelling were applied to optimize contaminant recovery and expedite closure. This project assumes significance in light of the current regulatory trends in India, where a framework for assessment and remediation of contaminated sites is being developed.

Preliminary investigations in 2004-05 indicated elevated concentrations of CVOCs including tetrachloroethene (PCE) in Site soil and groundwater with onsite degreasing activities being the likely source. Soil vapor extraction (SVE) and Pump and Treat (P&T) system were installed to mitigate offsite migration of the impacted groundwater.

A total of 5,990 kilograms (kg) of CVOCs were removed using SVE. The P&T remedy has cumulatively removed over 1,400 kg of CVOCs from groundwater over 9 years of operations and achieved more than 99.99% reduction in dissolved phase concentrations. The P&T system is expected to operate for a few more years before achieving remediation goals of WHO drinking water standards. In spite of limited regulatory framework for managing contaminated sites in India, the Site has successfully implemented remediation.

CETP: A New Approach using Advanced Technologies and Automation

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Keywords: CETP, wastewater, pollution, AOP, SBR.

With more than 170 CETPs operational in India, it remains critical issue to evaluate the performance of these final check points before discharging the effluent in the nature. Reliability of this final check points remains one of the biggest challenges in the recent times. The concept started as a solution has become a big problem itself. The technologies implemented at CETPs are by enlarge based on conventional treatment methods like ASP, which were mainly used for STPs. STPs has progressed in terms of treatment technologies, but CETP treatment philosophy remains unchanged over the years. New STPs are being designed with advanced technologies like SBR and MBR. CETP designs need to re-looked with a new approach using available advanced technologies like SBR, AOP and membrane processes. Technologies based on membrane filtration can benefit to recycle and reuse the effluent. This will reduce the huge burden on the natural resources. Advanced oxidation options can be adopted for reducing recalcitrant COD. A new technology for primary treatment-SBPT can be effectively used for better TSS removal.

Automation of operations will reduce the human interference for better treatment efficiency, e.g. installation of level based automation (low, medium and high) will increase the equalisation efficiency of existing tank. Existing CETPs can refurbished by adopting PLC-SCAD based automation techniques. With automation techniques and availability of advances technologies, a new approach can be developed to improve the CETPs performance, leading to recycle and reuse of water.

NATURE-BASED TECHNOLOGY SESSION

SMART Biochar - an environmentally sustainable means in removing water contaminants or soil immobilization

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Keywords: fast pyrolysis, slow pyrolysis, biochars, metals removal, sustainable green adsorbent.

Global threats including climate change, land degradation, environmental contamination, and water shortages lead to economic, social and environmental damage. These need to be addressed to overcome the major disaster occurring now and in near future. Sustainable Biochar (BC) from biomass and wastes can be an environmentally-friendly option for carbon sequestration, soil fertility improvement, pollution remediation and agricultural by-product/waste recycling. An abundance of agricultural residues/byproducts exist and other crops that can easily be converted into bio-energy with bio-char as byproduct. The biochar produced can be burned or added into soils where its long-term duration, which can exceed centennial timescales, sequesters carbon while also improving soil fertility, structure and reducing fertilizer run-off. Biochar application to water and wastewater treatment is less explored. Use of biochars byproducts as low cost green adsorbents without further modification could also provide a value-added outlet.

Both slow and fast pyrolysis biochars were developed, characterized and utilized for environmental management including remediation of organic and inorganic contaminants from water, improving soil fertility and carbon sequestration as a strategy for climate change mitigation. Magnetic biochars containing fused iron oxides were also prepared and used for contaminants remediation. The morphologies and surface chemistries of magnetic and nonmagnetic biochars were studied. Sorption studies demonstrated that low surface area biochars have remarkably high capacities for contaminants remediation. This occurs due to permeation of water into the chars' 3D structure where adsorption/coordination sites exist. Biochars swell in water due to oxygen-function present below pore surfaces and distributed throughout. Char performances were evaluated using different models. Dominating mechanisms responsible for contaminants remediation have been established. The biochars from the pyrolysis/gasification (thermochemical platform) producing biooil or bio-syn gas from biomass seems to be a practical, effective and environmentally sustainable means in removing water contaminants or soil immobilization.

Biological processes and methodologies to characterize useful traits for selecting plants with improved phytoremediation ability

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Keywords: heavy metal, organic compounds, pharmaceuticals, plant physiology.

To counteract the presence of the anthropogenic organic and inorganic compounds, dramatically increasing in water and soil in the last decades, plants have evolved a wide array of morphological, physiological and biochemical traits allowing them to avoid or limit the absorption or, in contrast, to degrade and/or accumulate and safely store these chemicals at cellular and tissue levels. Such processes represent the basic properties to be exploited for the utilisation of plants in the decontamination of soil and water through the bio-technology called phytoremediation. Really effective and extensive applications of phytoremediation need the availability of selected plant material able to tolerate and accumulate/degrade pollutants in different environmental conditions. Therefore, the characterization of the morpho-physiological and bio-molecular traits involved in these processes represents a key point to assist the selection of plants for phytoremediation. Such characterization is an ongoing task for our laboratory. Specifically, the setting up and application of biometric indices, the utilization of non-destructive, non invasive tools such as chlorophyll fluorescence image and X-ray fluorescence analysis, the biomolecular characterization of the antioxidative pathways are successfully performed. Regarding the methodological approaches, our laboratory is currently utilising the "*in vitro*" culture selection [1], eco-toxicological plant bioassays [2], hydroponic culture screening in growth chamber [3,4], pot experiments in greenhouse and upper-scale growth performance test in mesocoms under open-field conditions [5]. Different plant species were successfully investigated, ranging from aquatic plants as duckweed, riparian plants as poplar and willows, to woody or herbaceous species useful for biomass production such as eucalypt and amaranth.

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Assessment of impact of climate change on water resources in a coastal aquifer by finite element modelling

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Keywords: seawater intrusion, groundwater, mitigation, numerical modelling.

Seawater intrusion is a major problem affecting the costal groundwater resources in several parts of the world. The coastal aquifer system located the north of Chennai city, India is affected by seawater intrusion since the year 1969 due to over extraction of groundwater for agriculture and drinking water supply to the city. Change in the rainfall pattern due to climate change may also lead to uncertainties in the supply and management of the groundwater resources. A density-dependent numerical groundwater model was used to assess the impact of climate change in this aquifer. Since the climate change projections for this area is available until the year 2030, the density-dependent model was used to predict the changes in hydrological stresses on the groundwater head until this year. The model predicts that a 10% increase in rainfall recharge with additional check dams and 1 m increase in crest level of all the check dams will increase the groundwater head by about 3 m in the upper and 5.5m in the lower aquifers. Also, this will lead reduction in the chloride concentration by about 1000 mg/l in the upper and 700 mg/l in the lower aquifers respectively. Thus, the additional recharge from the proposed structures and 10% increase of rainfall due to climate change will decrease the chloride concentration and partially restore this seawater intruded aquifer by the year 2030.

The dual role of ostracods in polluted sites: sentinels of anthropogenic impacts and bioassays animals

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Keywords: Environmental parameters, Ecotoxicity, Biotechnology.

The response of ostracods to different environmental conditions and anthropogenic impacts has been investigated in different settings worldwide [1,2]. Physical–chemical characteristics of waters, hydraulic conditions, sedimentation rates and bottom grain sizes influence the development of both a single ostracod species and an assemblage. Besides population and community changes, morphological and geochemical changes can also be detected in the ostracod carapace, operating as a tracer of the water quality. All these characteristics allow to determine the spatial effects of anthropogenic pressures. In addition, recently developed bioassays suggest that ostracods may be included among the most promising sentinel groups in freshwater to brackish areas [3]. They show high sensitivity to the increasing amount of toxic material, pesticides, herbicides, heavy metal pollution and oil inputs reaching the aquatic ecosystems. The constant research for the most sensitive and locally important species in a particular aquatic ecosystem has opened the door to a variety of micro-invertebrates as potential standard bioassay animals. The species richness of ostracod communities and the cosmopolitan distribution of many species are additional factors that are attractive for potential bioassay animals. *Heterocypris incongruens* (Ramdohr, 1808), a species extremely sensitive to a broad spectrum of organic and inorganic toxicants, has been used to develop the Ostracodtoxkit F^{TM} [4], a toxicity kit applicable on freshwaters, sediments and soils. Ease of culturing and maintenance make it an attractive alternative to fish as bioassay animal. Finally, its life history and auto-ecological characteristics make it attractive for both acute and chronic bioassays.

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Application of isotopes in hydrological studies with special reference to water quality

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Keywords: Isotope, sub-surface, contamination, water dynamics.

Water in environment chemically evolves by interacting with geological minerals, external pollutant sources and internal mixing among different water bodies along specific flow-paths in the surface/subsurface. The source attribution, characteristics of pollutants level and transport in water bodies, extent of pollution, processes governing pollution and containment of its spreading are altogether different at different scales of investigations and are associated with variations in one or two parameters at one scale and several parameters at another scale. In a watershed, gradients in water quality and contaminant levels can have a variety of configurations, depending on pollutant concentration in recharging groundwater over time, and the distance, direction and time between recharge and discharge of polluted water and the distribution and effectiveness of natural remediation (e.g., denitrification, dissolution of minerals, chemical weathering).

The advanced isotope techniques, in this context, offer potential tools for tracing sources and sinks of various pollutants in large river basins, and to have detailed insight into many of the long-term processes related to the aspects governing groundwater dynamics, in integration with chemical information, groundwater recharge and contamination characteristics, residence time (age) in the aquifer, groundwater-surface water interactions, flow regime, pathways and mixing processes in groundwater system. During the last two decades, application of isotope techniques has increased significantly. Temporal and spatial variations of isotopes and chemical constituents in groundwater are employed for improved understanding and elucidation of: (a) system boundaries, (b) mechanism and potential sources of pollution, and (c) dynamic parameters related to pollutants movement.

SWINGS project: Safeguarding water resources in India with green and sustainable technologies

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Keywords: India, rural areas, sustainable wastewater treatment, treatment wetlands, water reclamation.

SWINGS is a project (2012-2016) funded by the EC and DST (GoI), aiming at implementing decentralized low-cost technologies for treatment and reuse of wastewater in rural areas of India. Innovative combinations were implemented with the aim of enhancing the treatment capacity and providing an effluent suitable for its further reuse. This approach enhances wastewater reclamation, low energy consumption and production of useful by-products from the process as secondary resources (e.g. aquaculture, irrigation of agriculture and green areas, toilet flush, washing), therefore safeguarding the local drinking water supply in India.

Pilot plants which combine different treatment methods have been deployed at 3 locations of India. The largest system is located at Aligarh Muslim University (Uttar Pradesh), which comprises various constructed wetland configurations, anaerobic digestion and solar-powered disinfection methods treating the wastewater of the campus. Smaller pilot plants were located at Kalyani University (West Bengal) and Indira Gandhi National Tribal University (Madhya Pradesh), containing filtration methods followed by solar-powered disinfection methods (anodic oxidation and UV light) treating urban wastewater. After design, construction and commissioning of the plants the systems are currently in steady-state operation, and periodically monitored so as to evaluate their treatment capacity and to optimize the technology to the local conditions. A sustainable *E. Coli* onsite monitoring technique was applied for operational monitoring and verification of the efficiency of the disinfection. Moreover, a Decision Support System (DSS) was developed so as to facilitate the selection of a certain treatment technology for a specific scenario.

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SENSING TECHNOLOGY SESSION

Miniaturized sensor for monitoring antibiotic residues in water

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Keywords: molecularly imprinted polymers, electrochemical impedance spectroscopy, pencil graphite electrode, tetracyclin, streptomycin.

Indiscriminate use of antibiotics in agriculture, food and environmental has resulted in increased presence in water and environment. The presence of antibiotic residues increases the risk of antibiotic resistance. Thus, there is need for sensitive yet low cost on site analysis with ability to detect within permissible limits. Among the biosensors, label free immunosensors recently have gained significant attention owing to their high selectivity and sensitivity [1]. Impedimetric sensors have significant advantage of providing rapid yet sensitive analysis with capability for onsite analysis. Using both natural antibodies and synthetic antibodies (Molecularly imprinted polyers) a novel impedimetric sensor for analysis of antibiotic residue (Tetracyclin) has been demonstrated. The imprinted polymer was prepared on pencil graphite electrode for low cost analysis. The sensor can detect tetracyclin, meeting regulatory standards in drinking water. Good recoveries were obtained in drinking water and treated water.

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Development of an ultrasensitive technique for determination of date rape drugs

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Keywords: date-rape drug, ketamine, paper based sensor, electro-oxidation.

The objective of the present invention is to develop an ultrasensitive technique for the electro analysis of rape drug. Ketamine is a well-known anesthetic drug used in medical industry that produces a wide range of sedative effects. However there has been a growing concern about the illegal usage of such hypnotic drugs spiking them in alcoholic drinks above their permitted dosages. To avoid rape crimes on unwilling victims, there is need to develop a sensitive approach for determination of ketamine. It involves fabrication of devices based on metal based electrodes and paper based electrodes modified with nanoparticles. A metal based electrode modified with nanoparticles exhibits some disadvantageous features such as high cost and large sample requirements while paper based electrodes offers many advantageous features such as facile approach, economical, less volume requirement and have potential for commercialization. The developed sensor was tested in real time samples like alcoholic and non-alcoholic drinks. The hyphenation of device is for detection of date rape drug i.e. ketamine has immense prospective for field-testing platforms.

A low cost portable genosensor for detection of Dengue virus infection

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Keywords: Dengue virus, biosensor, DNA, nano-composites.

Current research work involves an electrochemical microfluidic paper-based analytical device (EμPAD) integrated with Pt-Pd nanocomposites for detection in patient infected with dengue at the point of care by employing DENV DNA. EμPAD offers many advantageous features such as portable, facile approach, economical and have potential for commercialization. Methylene blue (MB) was doped as an intercalating agent for sensing DENV DNA. The proposed sensing scheme is highly feasible for future clinical applications. In addition, the novel methodology is adopted for detection of Herpes virus. The device showed high selectivity, repeatability, and sensitivity.

Towards the development of novel nano-architectures for biosensing applications

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Keywords: nanomaterials, graphene, electrochemical biosensors, sensitivity.

Recent advancements in the area of miniaturized sensors and devices necessitate the development of nano architectures. Moreover, development of three dimensional hierarchical structures from nano-building blocks is of current research interest due to their potential applications in the research area of environmental protection, sensing, gas storage and energy [1-3]. However, a great challenge during the construction of such architectures through covalent linkage is to retain the native properties of the individual nanomaterials such as high conductivity, large surface to volume ratio, excellent electrochemical properties etc. In this presentation, the design and assembly of cross-linked three dimensional architectures using a solution based covalent binding of individual nanosheets for the electrochemical biosensing application will be discussed [4].

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Biosensors as screening tools for environmental analysis

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Keywords: electrochemical biosensors, environmental screening analysis.

The use of sensor-based analytical methods is gaining increasing interest in the fields of environmental toxicity, for ecosystem monitoring and testing of crops and foods of animal origin, clinical diagnosis and therapy. The increased interest in sensor–based techniques is proven by the significant number of both scientific papers and registered patents on this subject. Multidisciplinarity between chemistry, material sciences, biochemistry, molecular biology, physics, μ-electronic technologies, and engineering has created important new ideas in several research fields, including biosensing.

Increasing number of potentially harmful pollutants in the environment calls for fast and cost-effective analytical techniques to be used in extensive monitoring programs. In this context, biosensors appear as a suitable alternative or a complimentary analytical tool.

Biosensors can be used as environmental screening tools in the assessment of environmental quality or for the chemical monitoring of both inorganic or organic pollutants: heavy metals, biochemical oxygen demand, nitrogen compounds, polychlorobiphenyls, phenolic compounds, endocrine disruptors and hormones, organophosphorous compounds, herbicides, particulate matter.

Advances in biotechnology and nanotechnology may be able to provide more sensitive and stable detection systems for air and water quality monitoring, allowing the simultaneous measurement of multiple parameters and real time response capability.

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OTHER CONTRIBUTIONS

Use of ligninolytic mushrooms for bioremediation

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Keywords: mycoremediation, phenols, oxytetracycline, polycyclic aromatic hydrocarbons.

Several studies regarding bioremediation by means of fungi and their enzymes have been performed in the Institute of Agro-Environmental and Forest Biology (CNR - IBAF) for many years. The ligninolytic mushrooms resulted active in applications for soil decontamination and wastewater treatment, producing degradation of phenols, oxytetracycline [1] and polycyclic aromatic hydrocarbons (PAHs). In particular the bioaugmentation technique was applied with the addition of mycelium for the treatment of Olive Mill Wastes, with a strong reduction of phenols and the production of fungal biomass, useful for the extraction of high added value compounds like glucans and chitin [2]. *Pleurotus ostreatus* ability in PAHs degradation was tested utilizing a creosote contaminated soil and creosote-treated wood (sleepers). Results showed a good PAHs degradation in both cases [3,4]. Ligninolytic mushrooms are known to produce the enzymes laccases both in the presence of lignocellulosic substrates and constitutively, in some phases of their life cycle. Since laccases are extracellularly produced, their purification is simple and cheap. They can be particularly suitable for biotechnological applications, because their thermal stability and resistance to pH and chemical agents can be increased immobilizing them on solid supports. A new laccase based biocatalyst supported on a natural clinoptilolite was prepared in IBAF, which resulted efficient in chlorophenols removal [5].

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Effective Novel Photocatalytic materials for improved indoor environment

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Photocatalysis is considered a promising and effective method for air purification and the most advance oxidation process to resolve environmental problems. Metal oxide semiconductors are commonly used as photocatalysts. TiO_2 photocatalyst in particular has been extensively studied for air depollution due to its low cost, innoxiousness, chemical inertness, and high photocatalytic efficiency under UV light. However the photocalytic properties of TiO2 may be extend to the visible light region by appropriate doping with metals and nonmetals. In this work, we report on the synthesis and characterization of TiO2 materials doped with transition metals in different concentrations capable to be activated under visible light irradiation i.e. suitable for indoor applications [1].

In addition, we report on the material anti micro-bacterial effectiveness through the inactivation of *Escherichia coli* and *Klebsiella pneumoniae* pathogens by means of heterogeneous photocatalysis under simulated solar irradiation. For this purpose, novel Mn-, Co- and Mn/Co-doped TiO_2 catalysts were synthsized [2]. The effect of various operating conditions, such as metal dopant type (Mn-, Co- and Mn/Co), dopant concentration (0.02-1 wt%) and catalyst concentration (25-250 mg/L) on bacterial concentration (10^2-10^8 CFU/mL), treatment time (up to 60 min), toxic effects on bacteria were examined. Metal-doped TiO_2 demonstrated an activity superior to the respective of commercially available P25 titania.

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Exploring possibilities of Scientific Collaboration between Leading Scientific Institutions from India and Italian National Agency for New Technologies, Energy and Sustainable Economic Development

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Keywords: scientific collaboration, memorandum of understanding, renewable energy, transfer of technical know-how, joint research proposal, technical meetings.

Desiring to further strengthen their on-going scientific and technological cooperation both ENEA in Italy and few leading scientific /technological institutions in India, have agreed upon to step up their joint efforts to identify R&D areas (focused predominantly on renewable energy sources) through formal collaboration by means of signing a Memorandum of Understanding (MoU). It is worth to mention that as result of above-mentioned initiatives, ENEA from Italy and Madan Mohan Malaviya Technical University (MMMUT) Gorakhpur, very recently, most precisely on Sept. 28, 2016, signed a MoU. Also, following the similar trend, a few others high esteemed technical institutions from India (IIT Delhi, MANIT Bhopal, GHRCE Nagpur, etc.), are in the process of signing MoU with ENEA. Needless to say that implementations of above-cited accords (MoU) will help both the nations to help reduce the huge amount of carbon emission into the atmosphere, global temperature rise, threats of climatic changes, etc. Moreover, identification of investors from the private sector, in India, interested in acquiring co-generators for the production of both thermal and electric power from biogas, will certainly serve as a link to industrial outfits in Italy with demonstrated technical competence in this specific area. Last but not the least, important joint efforts will ensure a wide-range networking of the relevant scientific communities / stakeholders and systematic establishment of linkages between the on-going research and innovation projects from both India and Italy. It is further expected that the partnership will contribute to the broader context of the governments initiatives to strengthen cohesion of both the nations towards strategic Science and Technological co-operation, with high impact factor on implementation and economic consequences.

Human Geoscience Solutions for Clean Water and Sanitation for Sustainable Development Goals

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India has in its possession 14 major, 55 minor and 700 small rivers which has been regarded as the backbone of Indian economy, potable water, electricity and livelihoods. India has occupied 4 per cent of water resources, 2.4 per cent land and 17 percent people in the world. This imbalance further resulted into crisis in securing water to its people.

One third of India's district are affected by severe drought, affecting some 330 million people in 256 districts in 10 states. There are in total 140 major lakes in India, a supporting economy to human settlement, facing problems of contamination due to domestic sewage, agricultural run-off, discharge of industrial effluent, over fishing and expansion of city boundaries. But pollution and improper utilization of river water resulted into water crisis in India.

In light to the complex issues regarding the water resource there are various programmes by the government like National Rural Drinking Water Programme (NRDWP), Swachh Bharat Mission (Gramin), Swachh Bharat Kosh, Ganga Action Plan (GAP) and Information, Education and Communication (IEC). With the rising demand and needs, it is imperative to find innovative geographical solutions to conserve and clean the available water resources. The research hereby proposes to suggest human geo-science solutions to achieve clean water and improvement in sanitation for sustainable development goals.

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