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RESEARCH ARTICLE

A REVIEW: IMPORTANT ROLE OF MICROORGANISMS IN DEALING ENVIRONMENT PROBLEM

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ABSTRACT

Microbial diversity is an important component of the overall global biological diversity. Recent technological advances in exploring microbial diversity have revealed that a large proportion of microorganisms are still undiscovered and their ecological roles are largely unknown. Careful selection of microbes and intelligent design of test assays are the key steps in developing new technologies for effective utilization of microorganisms for sustainable agriculture environmental protection, human and animal health. Several microbial applications are widely known in solving major agriculture and environmental issue. Waste water treatment and recycling of agriculture and industrial waste are other important uses of microbial technology. Bioremediation is the most effective management tool to manage the polluted environment and recover contaminated soil. Interaction of microorganisms (Bacteria, Fungi and Archaea) with their abiotic environment role of microorganisms for soil development and essential part of living soil and most importance for soil health. They can be used as indicators of soil health. Microbial indicators of soil health and recommends specific microbial indicators or soil ecosystem parameters representing policy relevant and points. In the present paper large number of published and available literature is reviewed.

INTRODUCTION

Environment literally means surrounding and everything that effect an organisms during its lifetime is collectively known as its environment. It includes all the physical and biological surrounding and their interactions. Environment studies provide an approach towards understanding the environment of our planet and the impact of human life upon the environment. The environment is actually global in nature. The environment "super challenges" of the twenty first century have become quite clear in the last increase in the last several years. Climate change due to the vast increase in the production of greenhouse gases is real (Crowley, 2000). There is a genuine need for renewable energy supplies (cook, *et al*. 1991; Jackson, 1999). Constant threats of pandemics such as the Asian flu, mad cow disease, the outbreak of Legionella (Temmer man *et al*. 2006). As well as water shortages, shrinking agriculture productivity, and environmental contamination comprise some of the important issue. A wide variety of microorganisms are present in soil, water, air and in association with plants and animals. These diverse communities constitute "a metagenome of knowledge".

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This metagenome also extends to microbial communities both inside and out of the body. Because of their metabolic actions, they are major players not only in our health and well-being but also in environmental sustainability (Verstaete *et al*., 2007).

Microorganisms in management of environmental problem

Environmental pollutants in soil and water are a major concern worldwide. Many toxic, mutagenic and carcinogenic elements pose serious threats to the environment and public health. Contaminated water and waste water can be treated by means of chemical, physical, and biological means to remove and/or detoxify it. Similarly, various methods such as thermal desorption and land filling can be used to treat contaminated soil. But these soil treatments do not effectively restore natural flora a fauna. Bioremediation, i.e. the use of microorganisms to remove toxic pollutant from the environment, is the most promising technology that is ecofriendly, safe, and effective even if the pollutants are present at low concentrations. (As in the case with heavy metal removal from water) (Labana, *et al*. 2005; Singh, 2006; Zafer, *et al*. 2007; Lal, *et al*. 2010). Many site specific microorganisms are capable of carrying out bioremediation reaction and many have already been used of sites previously contaminated with polycyclic aromatic hydrocarbons (PAHs), nitro aromatic compounds, chlorinated organic etc. (Samanta, *et al*. 2002; Zocca, *et al*. 2004; Carvalho, *et al*. 2005).

Ecosystem development

Microbial communities can be considered as architects of soils (Rajenddhran and Gunasekaran, 2008). And many ecosystem services that are linked to terrestrial ecosystem, including plant production, are closely linked to microbial activities and their functional trails (Torsvik and Ovreds, 2002). Vice Versa, the soil matrix as well as chemical and physical properties of soils, like quality and amount of soil organic matter, pH, and redox conditions, have a pronounced influence on dynamics of the microbial community structure and function in soils (Lombard, *et al*. 2011). This close interplay between abiotic conditions and the soil biosphere is one of the most fascinating issues as far as earth sciences are concerned, with huge implications on environmental as well as human health (Van Elsas, *et al*. 2008). Due to the complex interactions, it is not surprising that the formation of soils with a high level of fertility is a result of more than hundreds of years of soil “evolution” (Harrison and Strahm, 2008). As a result of global change in general and the loss of soil quality in particular many soils are threatened.

Microorganisms in agriculture environment

There is a growing worldwide demand for sound and ecological compatible environmentally friendly techniques in agriculture, capable of providing adequate nourishment for the quality and quantity of certain agriculture products. For these reason the application of beneficial microorganisms is an important alternative to some of the traditional agriculture technique which as it has been well documented, very often severely alter the agro ecosystem balance and cause serious damage to health for example, contamination of ground water by leaching of nitrogen fertilizers accumulation of nitrates and persistence of chemicals used in crop protection in edible portion of foods are cause of grave concern. The use of beneficial microorganisms in the replacement or the reduction of chemicals has been so far attested (Dobbelaere, *et al*. 2003; Burdman, *et al*. 2000).

Beneficial microorganisms such as diazotrophs bacteria, biological control agents (BCAs), plant growth promoting rhizobacteria (PGPRs) and fungi (PGPFs) can play a key role in this major challenges as they fulfils important ecosystem functions for plants and soil (Whipps, 1997; Raaijmakers *et al*. 2009; Hermosa *et al*. 2011). The use of beneficial microorganisms is mostly oriented to improve plant growth and protection in a agriculture context, nevertheless several applications in a wider environmental sense could be prospected, as reported by our group in scientific literature. Pseudomonas fluorescent (Russo, *et al*. 1996; 2001; 2005), Bacillus Subtilis (Felici, *et al*. 2008), Rhizobium spp. (Toffanin, *et al*. 2000; Casella, *et al*. 2006) are some of beneficial bacteria applied in our experimental/ scientific work as biofertilizers and /or biocontorl agents in agriculture other potential applications currently include, micropropagation, bioremediation and phytoremediation, phosphate solubilization, soil aggregation, sewage treatment, bioleaching, oil recovery, coal scrubbing and biogas production.

Microorganisms in soil environment

Microorganisms respond quickly to environmental stress compared to higher, organisms as they have intimate relations with their surroundings due to their high surface to volume ratio. In some instances, changes in microbial populations or activity can precede detectable changes in soil physical and chemical properties, thereby providing and early sing of soil improvement or an early warming of soil degradation (Pankhurst, *et al*. 1995). An example is the turnover rate of the microbial biomass. This is much faster, e.g. 1-5 years, than the turnover of total soil organic matter (Carter, et *al*. 1999). The bioavailability of chemical, e.g. heavy metals or pesticides is also an important issue of soil health because of its connection with microbial activities.

The impact of such chemicals on soil health is dependent on microbial activities. The biological activity in soil is largely concentrated in the top soil, the depth of which may vary from a few to 30cm. In the top soil biological components occupy a tiny fraction (<0.5%) of the total soil volume and make up less than 10% of the total organic matter in soil. These biological components consist mainly of the soil organisms, especially microorganisms. Despite their small volume in soil microorganisms are key players in the cycling of nitrogen, sulphur, and phosphorus in and the decomposition of organic residues. Thereby they affect nutrient and carbon cycling on a global scale (Pankhurst, *et al*. 1997). That is, the energy input into the soil ecosystems is derived from the microbial decomposition of dead plant and animal organic matter. The organic residues are in this way converted to biomass or mineralized to Co2, H2o, mineral nitrogen, phosphorus, and other nutrients (Bloem, *et al*. 1997). Mineral nutrients immobilized when microbes are grazed by micro bivores such as protozoa and nematodes (Bloem, *et al*. 1997). Microorganisms are further associated with the transformation and degradation of waste materials and synthetic organic compounds (Torstensson, *et al*. 1998).

Microorganisms degrading wastes in environment

Environmental biotechnology plays an important role in agro ecology in the form of zero waste management in agriculture and most significantly through the operation of over 15million biogas digesters worldwide (Wikipedia.org.zylstra and Kuker, 2005; Vidya, 2005). Hazardous contaminants are harmful to man and other living organisms like cattle, livestock and plants in general. Naturally occurred microorganisms degrade contaminants through their metabolic processes and this property of microbes has been exploited in bioprocess technology. Microorganisms can also degrade hazardous organic waste such an polycyclic aromatic hydrocarbons (PAH) pesticides, polychlorinated biphenyls (PCBs) metals nitrogen, compounds, halogenated organic solvents and compounds, non chlorinated pesticides, herbicides and radio nuclides easily. Microorganisms have expanded the environment they were live in, by evolving enzymes that allow them to metabolize various manmade chemicals (that is xenobiotics) (Okpokwasli, 2007). Bioremediation is the use of microorganisms or microbial processes to detoxify and degrade environmental contaminants. Microorganisms have been used for the routine treatment and transformation of waste products from several years (Okpokwasili, 2007). The fixed film and activated sludge treatment system depend on the metabolic activities of microorganisms which degrade the waste to enter in the treatment facility. Several waste treatment plants are specialized and contains selected and acclimated microbial populations which are often used to treat industrial effluents (Okpokwasili, 2007). Microorganisms remove toxic heavy metals from environment by various mechanisms. Analytical techniques targeting 16s rDNA or functional genes were widely used for microbial quantification. These include hybridization-based techniques, such as membrane hybridization (Rakesh, *et al*. 1995). And fluorescence in situ hybridization (FISH) (Okabe, *et al*. 1999). As well as polymerase chain reaction (PCR) based techniques, such as denaturing gradient gel electrophoresis (DGGE) (Muyzer, *et al*. 1993). And cloning-sequencing (Zhang and Fang, 2001; Zhang, *et al*. 2003). Hybridization methods which have detections limits in the order of 105 DNA/RNA copies or greater, are in general less sensitive. They can thus only be used for environmental samples of relatively high microbial concentrations.

Microorganisms' biosensors in environment

Microorganism's biosensors are analytical devices capable of sensing substance in the environment due to the specific biological reactions of microorganism or its parts. Microorganisms have a huge potential for detection of a wide spectrum of chemical substances and their mixtures they are adjustable to different reaction conditions and compared to enzymes or antibodies do not require expensive preparation processes (Shin, 2012, Xu and Ying, 2011). They can be genetically modified to this characteristics enables the use of microbial biosensors in the field of environment monitoring, food safty and medicine. Human population growth and the associated increased demands of water pose risks to maintaining acceptable water quality. Government agencies oversee environmental management to maintain water quality, assure the public health and preserve the environment. Environmental monitoring includes measurements of physical characteristics (e.g. pH, temperature, conductivity, chemical parameters (e.g. oxygen, alkalinity, nitrogen and phosphorus compounds) and abundance of certain biological taxa. Bioindicator taxa range from the microscopic, such as *Escherichia coli* or enteric viruses for fecal contamination and various algal taxa for trophic states, to microorganisms such as insects and fish for pollutant or temperature effects and trophic status (US EPA, 1990). Monitoring could also include assays of biological activity such as alkaline phosphate (Overback and Chrost, 1990). Microbes can be very informative for environmental monitoring since their short generation times allow then to respond rapidly to changing environmental conditions. Molecular methods are commonly used in environmental microbiology research, but have not gained routine use for water quality assessments in support of environmental management. In fact, no molecular biological based method is currently approved by the EPA to monitor water for fecal contamination although work in this area is now rapidly progressing (Santo Domingo *et al*. 2003; Dick and Field, 2004, Haugland, *et al*. 2005). Microorganisms play a fundamental role in environmental processes and ecosystem services, including nutrients cycling and organic matter decomposition (Wider, Bonam and Allison, *et al*. 2013; Creamer, *et al*. 2015; Chin, McGarth and Quinn, 2016). Bioremediation of contaminated habitats or waste systems (Haritash and Kaushik, 2009; Oller, Malato and Sanchez-Perez, 2011). And influcing greenhouse gas emissions (Singh *et al*. 2010; Bragazza *et al*. 2013; Hu, Chen and He, 2015). The ability to use and manipulate these processes has great potential for societal and environmental application, particularly in extremophiles which frequently reveal metabolic capabilities, and evolutionary solutions not witnessed elsewhere in the microbial world (Coker, 2016). However, it is rarely possible to directly link the presence of a specific microbial taxon to a particular ecological process. Other methodological challenges include establishing the relative importance of biotic and abiotic factors in microbial ecosystem function, and determining the appropriate spatial and temporal scale necessary to discriminate links between microbiota and their ecological functions (Bissett, *et al*. 2013). Concurrently a deeper understanding is required of human-induced impacts on global microbiome through urbanization habitat degradation, climate change and the introduction of invasive species, amongst other.

Conclusion

There is a consequent increase in the rate of resource utilization and environmental perturbation. On the other hand, there is a greater need to sustain and increase agricultural productivity and human health. Unexplored microbial diversity and available culturable microbes the main bioresource to be exploited to solve the major challenges of twenty first century. The genetic potential of various extreme habitats are considered to be useful for industrial technology. Further research and extension will go a long way towards application of microbes for the improvement of environmental quality, agricultural productivity, and human health and for novel uses such as global climate change, crops, new drugs development, and transgenic development. Soil microorganisms appear to be very suitable and sensitive early warning indicators or predictive tools in soil health monitoring. Soil health monitoring programs may thus benefit considerably by including microbial indicators. On the basis of above discussion it can be concluded that there is ample scope of research in the field of environment in microorganisms.

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