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Effective Bio-methods in Defending Biodiversity from Pollution with special focus on Ethiopia, N E Africa -A Review

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ABSTRACT

"The nation that destroys its soil destroys itself."
-- *Franklin Delano Roosevelt*

Unfortunately, our affluent society has also been an effluent society. Man's attitude of dumping the unwanted things into the surrounding environment has reached an alarming proportion. Among different hazards of biodiversity, pollution is a serious problem, which drastically affects all types of species found in various natural habitats. Biotechnology has its contribution in the treatment of such threats. Soil pollution is the addition of undesired substances such as toxic and harmful chemicals, salts, pathogenic microorganisms and radioactive elements to the soil layer, which decrease soil fertility by reducing its mineral content and adversely affect plant and animal survival. Various factors that cause pollution include fluorides, excessive nitrogen fertilization, weedicides, land degradation, soil erosion, and desertification. Soil pollution can be controlled by various Bio-Methods like biostimulation, bioaugmentation, packaged microorganisms, biosorption, bioremediation, bioventing, biological deodorization processes, vermin technologies, root zone treatment and bio-leaching. All these methods are useful to treat the pollutants to some extent but the main and important thing is the attitude of human beings towards struggling against pollution.

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Introduction

Biodiversity is defined as the variability among living organisms and also includes diversity within species, between species and of ecosystem. Dicastri and Younes (1990), Mc Neely *et al.* (1990), Bull and Hardman (1991), Hawkworth (1991) studied the biological species in the world.

Biodiversity is a new name for species richness of plants, animals and microorganisms occurring as an interacting system in a given habitat. Biodiversity cannot be superseded because the species adapt to a given habitat after a long period of time.

Over 250,000 species are lost and thousands are threatened to extinction is due to plasticity in their nature and unsustainable resources utilization, increased levels of pollutants (in water, soil and atmosphere) and other factors (FAO. 2007). If a species extincts, it means whole of the gene pool extinct. The true value of biological

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diversity lies in the information present in the genes. Therefore, there is an urgent need of protection of these endangered species, by controlling or at least by mitigating the effects of pollution on biodiversity.

Biodiversity in Ethiopia

Biodiversity is the variation of life forms within a given ecosystem, biome, or for the entire Earth. Biodiversity is often used as a measure of the health of biological systems. The biodiversity found on Earth today consists of many millions of distinct biological species, which is the product of nearly 3.5 billion years of evolution.

"Biological diversity" or "biodiversity" can have many interpretations and it is most commonly used to replace the more clearly defined and long established terms, species diversity and species richness. Biologists most often define biodiversity as the "totality of genes, species, and ecosystems of a region". An advantage of this definition is that it seems to describe most circumstances and present a unified view of the traditional three levels at which biological variety has been identified: gene, species and ecosystem.

Owning to its diversified agroclimatic zones, Ethiopia is rich in biodiversity in terms of animals, fisheries, vegetation and microbial life. It has also endemic flora and fauna.

Recent estimates of the total number of species range from 7 to 20 million (Alemayehu Negassa and Wiersum, K.F 2015), of which only about 1.75 million species have been scientifically described. The best-studied groups include plants and vertebrates (phylum Chordata), whereas poorly described groups include fungi, nematodes, and arthropods. Species that live in the ocean and in soils remain poorly known. For most groups of species, there is a gradient of increasing diversity from the Poles to the Equator, and the vast majority of species are concentrated in the tropical and subtropical regions.

Uses and values

Some measure of biodiversity is responsible for providing essential functions and services that directly improve human life. For example, many medicines, clothing fibers, and industrial products and the vast majority of foods are derived from naturally occurring species. In addition, species are the key working parts of natural ecosystems. They are responsible for maintenance of the gaseous composition of the atmosphere, regulation of the global climate, generation and maintenance of soils, recycling of nutrients and waste products, and biological control of pest species. Ecosystems surely would not function if all species were lost, although it is unclear just how many species are necessary for an ecosystem to function properly.

Threats

Human activities, such as direct harvesting of species, introduction of alien species, habitat destruction, and various forms of habitat degradation (including environmental pollution), have caused dramatic losses of biodiversity; current extinction rates are estimated to be 100–1000 times higher than prehuman extinction rates (Alemayehu Negassa and Wiersum, K.F 2015).

Diversity of Species

Plant Diversity

A. Field Crop Diversity

Ethiopia is one of the major vavilovian centers or origin for several domesticated crops and their wild and weedy relatives. It is an important primary and secondary gene pool for many field crop species that are useful sources of germplasm for economic traits in general and sources of genes resistance to diseases and pests in particular. Ethiopia is a primary gene center for field crops such as noug (*Guizotia abyssinica*), tef (*Eragrostis tef*) and the Ethiopian mustard (*Brassica carinata*). Besides, field crops such as barley, sorghum, durum wheat, finger millet, faba bean, linseed, sesame, safflower, chickpea, lentil, cowpea, fenugreek and grass pea have wide genetic diversity in Ethiopia.

B. Forest plant diversity

The forest resources of the country were grouped in to 5 categories, namely, natural closed forests, woodlands, bush lands, plantations and on-farm trees. The current area coverage of each category is not available. It was believed that about 35% of the landmass of Ethiopia was once covered with closed forests. The revised current estimate of the closed forest cover of Ethiopia was 3.5%. The total number of woody species of Ethiopia is estimated to be 1017, out of which 29 tree species, 93 shrub species and 2 liana species are endemic (Tadesse Woldemariam Gole *et al*., 2000). These species are represented in 104 families and 387 genera. Recently, a new tree species has been identified in the Ethiopian Somalli Region and has been named as *Acacia fumosa*.

C. Horticultural plant diversity

The major horticultural plant species grown in Ethiopia are categorized in five groups: root and tuber crops, fruits and nuts, stimulant and beverage species, herbs and spices and wild-edible species.

D. Medicinal Plant Diversity

Eighty percent of the Ethiopian people depend on traditional medicine for their health care (Dawit and Ahadu, 1993), and more than 95% of traditional medicinal preparations in Ethiopia are made from plant origin (Dawit, 1986; Mesfin Tadesse and Lisanework Nigatu. 1996).

E. Pasture and forage plant diversity

There are diversified pasture and forage resources adapted to different ecosystems of the country. Studies show that 736 species of grasses, 358 species of legumes and 179 species of browse trees are recorded so far in Ethiopia (Megeleta Oromia. 2003). Ethiopia is known to be a centre of origin and diversity to a number of herbaceous legume species including Trifolium, Vigna, and Lablab, among others.

Animal Diversity

A. Domestic animal diversity

Ethiopia has served as a gateway to domestic animals from Asia to Africa and its diverse ecology favored diversification of these resources. In terms of livestock population, Ethiopia stands first in Africa and 10th in the world in livestock population. The domestic animal population of the country is estimated to be 47.5 million cattle, 26.1 million sheep, 21.7 million goat, 1 million camel, 39.6 million chickens, 1.8 million horses, 0.4 million mules and 5.6 million donkeys (FAO. 2007).

B. Terrestrial wild animal diversity

Ethiopia is also endowed with diverse wild animal species, some of which are endemic to the political boundary of the country. There are about 284 species of mammals (Afework Bekele, pers. comm.), 926 bird species of which 23 are endemic and 19 are globally threatened (Lepage, 2006), 201 species of reptiles (over 87 snakes, 101 lizards and 13 species of tortoises and turtles), 188 species of fish, 324 butterflies and 63 species of amphibians (Colfer, C.J.P *et al*., 2007).

C. Aquatic wild animal diversity

There are about 30 major lakes, 12 major river basins and over 70 wetlands that are located in different ecological zones of Ethiopia. There are 188 fish species, 91 benthic and aquatic insects and 141 zooplankton species recorded so far from Ethiopia (FAO. 2007).

Microbial Diversity

Ethiopia's heterogeneous environmental conditions are favorable for diverse microorganisms. Ethiopia is rich in traditional microbial fermentation and preservation of foods and beverage. These valuable microbial genetic resources have not been sufficiently studied, documented, and conserved. Micro-organisms are of great value to

mankind because they benefit agriculture, industry, medicine, and environment in various ways. Actually, in the absence of microorganisms there could not exist life on our earth.
It is clearly known that the country is an important centre of diversity and origin of important cultivated plant species and domestic animals, many of which are still unknown and many endangered. So there is an urgent need for biodiversity rich countries to save it against destruction.

Among different hazards of biodiversity, pollution is a serious problem, which drastically affects all types of species found in various natural habitats.

Types of Pollution

Industrial growth in the 20th century also gave the room for new problems such as water pollution, air pollution, land pollution, noise pollution, radioactive pollution, solid wastes, depletion of resources, scarcity of good quality water, spreading health hazards, which are all the consequences of stupendous industrial activities. They can create problems to the environment and also the species present there. In the process of industrialization we are totally neglecting the pollution caused by it and their effect on natural resources. Along with industrialization other activities of humans such as urbanization, wrong agricultural practices, deforestation etc. are responsible for pollution.

Pollution is defined as an undesirable change in physical, chemical or biological characteristics of air, water, land that can harm lives of desirable species (plants, animals, microorganisms) and human life.

To prevent the damage to the biodiversity, caused by the pollution the following methods are adopted (Dubey, R.C. 1993; Dubey, R.C. and Maheshwari, D.K. 1999; Jogdand, S.N. 1995; Kumaresan, V. 1994; Purohit, S.S. 2003 and Sharma, P.D. 1996).

Methods Used to Control Pollution

- Biostimulation
- Bioaugmentation
- Packaged micro-organisms
- Biosorption
- Bioremediation
- Bioventing
- Biological deodorisation processes
- Vermitechnologies
- Root zone treatment

A. Biostimulation

It is the method of stimulating microbial activities in the waste treatment process. In this method maximum and rapid degradation occurs. It is also used in bioremediation of polluted land and ground water.

B. Bioaugmentation

It involves the addition of bacterial formulations externally to the waste-water treatment plants and polluted land. Bacterial formulations consist of freeze-dried bacterial suspensions and other additives like essential nutrients and wetting agents. Initially large doses are employed; later small amounts are enough to treat the pollutants on the land and in water.

C. Packaged micro-organisms

Commercially available micro-organisms are selected from various resources and subjected for genetic engineering to make them efficient degraders. Microbial cultures to be used are grown in large quantities and dried. Then the additives such as wetting agents, emulsifier, and nutrients are added to the dried cell cultures.

Various companies are marketing the products of packaged microorganisms for a range of treatment including BOD removal, degradation of toxic wastes, attack on oil spillage, improvement in methane generation, eliminating filamentous bulking in activated sludge process, degradation of recalcitrant toxic wastes (pesticides).

D. Biosorption

Metabolism independent binding or adsorption of heavy metals to living or dead cells, extracellular polysaccharides, capsules and slime layers referred to as 'Biosorption'. Metals may be deposited around the cells in the form of phosphates, sulfides or oxides.

The microbial removal of potentially toxic metal, metalloid species, radionuclides, organometalloids, metal particulates can be done from effluents and industrial waste-waters. This can result in detoxification and safe environmental discharge. Biotechnological methods developed on biosorption can provide alternative treatment methods for contaminated effluents and waste waters.

E. Bioremediation

Industrial pollution not only posses the problem of effluents contaminating surface water bodies but it causes release of waste gases contaminating the air, land and ground water. Millions of tons of hazardous wastes are added into soil and even reach the ground water.

Liquid and solid wastes are also added to the environment by accidental spillage leakage during the transport of chemicals. These types of wastes are treated by Bioremediation. It encompasses biological methods for cleanup of contaminated soil and ground water. It is also called as Biorestoration. During the process, microorganisms may use the contaminants as nutrients or energy source and degraded by co-metabolism results detoxification of contaminants.

F. Bioventing

It is also called soil venting or soil vacuum extraction. It is very easy and cheaper method. It is used for the removal of oily phase contaminants above the water table. Appearance of CO_2 is the indication of biodegradation activity.

G. Biological deodorisation processes

In this process, bad smell ingredients are decomposed by exploiting the metabolism of micro-organisms. These are characterized by low running costs, easy operation, maintenance and control, energy conservation, compact construction and room temperature treatment.

Biological deodorisation processes are applied in the food industry, in rendering plants, livestock farming, foundries, pharmaceutical industry, agriculture, treatment of animal wastes, sludge domestic garbage.

There are three types of biological waste gas purification systems in operation. These are (i) Bioscrubbers (ii) Biofilters (iii) Biotrickling filters.

H. Vermitechnology

It is the latest technology where application of earthworms is made for combating the waste disposal problems, for minimizing the pollution effects and to get useful products from wastes. Recycling of organic wastes brought about by growth of earthworms gives many useful products along with pollution control as an important aspect.

I. Root zone treatment

Root zone process was developed in the sixties in Germany and is fully commercialized today to treat industrial and domestic effluents economically efficiently and naturally. Reeds (Wetland plants) of species *phragmites* absorb oxygen through stomatal openings behind the leaves and transfer it to hollow roots. It then enters the root zone and promotes the growth of bacteria and fungi. These micro-organisms oxidize impurities in the waste waters.

Root zone process has been applied to different industries like food processing, petroleum refineries, chemical industries, breweries, and distilleries, plastic manufacturing, metal processing industry, pulp and paper industry.

Conclusion

All the above methods are useful to treat the pollutants in some extent but the main and important thing is the attitude of Human beings. Biodiversity is the source of economic growth of any country, discriminate use of resources reflects the state of development of the country. In our country, a large number of institutions are involved in conservation, utilization of biodiversity and controlling pollution which come under ministry of Environment and Forest, Agriculture and Science and Technology.

Ethiopia is predominantly an agricultural country. Therefore, the policy makers have to realize that conservation, sustainable utilization and pollution control must be placed at the fore front of all development agendas.

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