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A REVIEW STUDY ON PHYTOREMEDIATION BY PLANTS OF DIFFERENT POLULUTANTS

Renu singh

Institute-Department of Botany,T.D.P.G.College,Jaunpur Affliated to VBSP University,Jaunpur.

Abstract- There are many different kinds of pollution, such as contamination of the air, water, soil, sound, and mind. Earth formerly had a stunning scenery, but in the last century in particular, man has mercilessly exploited the earth resources.As a result, many approaches to pollution control are required.However, among all the techniques, plant-based phytoremediation of contaminants is the most effective way to reduce surface pollution.

Keywords-Pllution,Phytoremediation,Plants.

INTRODUCTION

In modern times pollution has become the biggest menace for the survival of the biological species There are various types of pollution eg. air, water, soil, sound and mental pollution. Earth was a beautiful landscape but man has ruthlessly exploited for his greed specially, in the last century. With rapid industrialization and random urbanization environmental pollution has become a serious problem. Over exploitation of open spaces, ever-increasing number of automobiles and demographic pressure has further aggravated the problem. There are various ways and means to mitigate the urban environmental pollution. Plan-ting of trees and shrubs for abatement of pollution and improvement of environment is an effective way and well recognized throughout the world. Earlier, the purpose of planting trees in urban areas was purely aesthetic. The incessant increase of urban environmental pollution has necessitated to reconsider the whole approach of urban landscaping and its orientation in order to achieve duel effect ie bio-aesthetics and mitigation of pollution. Proper planning and planting scheme depending upon the magnitude and type of pollution, selection of pollution- tolerant and dust scavenging trees and shrubs should be done for bioremediation of urban environmental pollution. Pollution, the major problem in cities, is compounded by the fact that there is no exhaust for the polluted air to escape(Agarwal. et.al. 1980). Landscape architects can solve the pollution problems related to urban landscape by creating a micro-climate

Pollution :-

Pollution is defined as 'an undesirable change in physical, chemical and biological characteristics of air, water and land that may be harmful to living organisms, living conditions and cultural assets. The pollution control board defined pollution as unfavourable alteration of our surrounding, largely as a hy product of human activities. The pollution may be due to human activities or natural ecosystems. Natural pollution contaminates the air by storms, forest fire, volcanoes and natural processes (methane from marshy lands). Nature by and large treats, recycles and makes good use of the pollutants and renders them less harmful, whereas man-made pollutants threaten the integrity of the nature.

Pollutants :-

The substances, which cause pollution, are called pollutants. Pollutant is defined as any substance that is released intentionally or inadvertently by man into the environment in such a concentration that may have adverse effect on environmental health Environment Protection Act, 1986 EPA, 1986) defines pollutant, as any solid, liquid or gaseous substance present in such a concentration as may be, or tend to he, injurious to environment.

Air Pollution :-

Air is necessary for the survival of all higher forms of life on earth. On an average, a person needs at least 30 lb of air every day to live, but only about 3 lb of water and 1.5 lb of food. A person can live about 5 weeks without food and about 5 days without water, but only 5 minutes without air. Naturally, every one likes to breathe fresh, clean air. But the atmosphere, that invisible yet essential ocean of different gases called air, is as susceptible to pollution from human activities as are water and land environments. According to the WHO report, about 10 to 15% of the total population of India is suffering from common cold, bronchitis, asthma, hay fever etc. These diseases are no doubt airborne and spread the infection from several hundred kilometers under favourable atmospheric conditions. Dust and soot in the air contribute to between 20 and 200 deaths each day in America's biggest cities. III health from microscopic particulates with tiny specks smaller than the width of a human hair can lodge deep in the lungs and are associated with respiratory diseases, heart attacks and premature deaths. The new research indicates elderly people suffer the most harm. In the United States the Environmental Protection Agency (EPA) currently sets the maximum allowable concentration of microscopic particles. at 150 µm/m3 of air. The air is being continuously polluted in urban areas through heavy traffic, industry, domestic fuel combustion, stone quarries, coalmines and various agricultural activities from the adjoining areas(Anigma, S. 2002). These particulates are no doubt dangerous to hurman health and environment causing various diseases to plants and animals, damage to properties including our cultural heritage, national monuments, archives etc. Dust concentration varies from place to place and hour to hour, diurnally depending upon traffic, type of industry etc(Anonymous 1981). The highest dust concentration tends to be in summer, reaching maximum during mid-day and late-afternoon. In some large cities where wind and temperature fall more steadily, the concentration of dust also reduces accordingly.

Criteria air pollutants :-

The five primary criteria pollutants include the gases- sulfur dioxide (SO_2), nitrogen oxides (NOx) and carbon monoxide (CO), solid or liquid particulates (smaller than 10 µm), and particulate lead.

Effects of Different Types of Air Pollutants :-

According to Agarwal, air pollution is broad term, which actually covers lots of different types of problems. They are, acid rain, domestic and industrial smoke, smog, greenhouse effect, particulates, radionuclides and ozone layer depletion.

Plant species for pollution control :-

While selecting the species for pollution control the following are the important characteristics could be considered. Plants should be evergreen, large leaved, rough bark, indigenous, ecologically compatible, low water requirement, minimum care, high absorption of pollutants, resistant pollutants, agro-climatic suitability, height and spread, Canopy architecture, Growth rate and habit (straight undivided trunk). Aesthetic effect (foliage, conspicuous and attractive flower colour), Pollution tolerance and dust scavenging capacity. Different types of leaves tend to have differences in several aspects of their surfaces. Some types of leaves have greater surface rigidity or roughness than other leaves, which may affect their stickiness or particle solubility Stickier leaves are better for collecting particles because more particles would stick to their surface(Cunningham et al. 1997). Therefore, certain plant leaves may be more useful for efficient dust capturing than other plants The various morphological features are also major factors for dust capturing by leaves The crown area of plants is depending upon the morphological features of the leaf. The various types of Morphological features viz shape, size and surface texture of leaf are discussed below: Leaves can be of many different shapes. Primarily, leaves are divided into simple a single leaf blade with a bud at the base of the leaf stems, or compound leaf- a leaf with more than one blade. All blades are attached to a single leaf stem. Where the leaf stems attaches to the twig with an axial bud.

Compound leaves may be palmate- having the leaflets arranged round a single point like fingers on the palm of a hand, or pinnate when the leaves are joined on the two sides of the stalk, like the vanes of a feather. The form of leaves is related with all their functions and their environment. In addition to photosynthesis, the leaf also carries out other exchanges with the atmosphere. It is through the leaf that the plant "breathes" (absorbs oxygen and releases carbon dioxide and generate energy) and transpires Epidermic tissues in the leaf contain stomata-microscopic openings like valves which regulate opening or closing, permitting or preventing preve transpiration, through which the plant loses the major part of the water it absorbs so as to allow further absorption by the roots. In most plants the stomata are located on the underside of the leaves(Barfield et al. 1992). Their function is regulated so that plants living in dry climates have a substantially smaller number of stomata than those in humid climates, where stomata are numerous and prominent Where humidity is low the stomata may actually be recessed or partly protected by soft hairs which can prevent excessive transpiration.

Choice of eco-friendly plant species in urban environment to mitigate airborne particulate pollution :-

During tree plantation in an urban environment little or no attention has been paid to evaluate the effect of trees on filtering the particulate matter(Kumar et.al,1995). New housing developments offer an opportunity

to control atmospheric particulate pollution through tree plantations. Trees such as Tamarind (*Tamarindus indicus*) having smaller compound leaves are generally more efficient particle collectors than larger leaves Particle deposition is heaviest at the leaf tip and along leaf margin. In the preliminary survey of dust fall on common roadside trees in Mumbai, carried out by Shetye and Chaphekar. reported that the shape of leaves of Mango (*Mangifera indica*), Ashoka (*Polyalthea longifolia*), Pongamia (*Derris indica*) and Umbrella (*Thespepsia popuinea*) trees captured higher amounts of dust as compared to other neighboring plants. Dochinger, a plant pathologist of USDA Forest Service, Ohio, reported that the filtering effects of evergreen trees are better than the deciduous trees In Singapore, it has been noted that a single row of trees planted with or without shrubs can reduce particulate matter by 25% and each hectare (2471 acres) of plantation can produce enough oxygen to keep about 45 persons alive(Dillaba et. al 1989). The value of trees in urban environment is now generally recognized not only aesthetically but also functionally in helping to make cities and towns agreeable places to live and work in. The first choice should be, therefore, to select easily propagated and readily available, medium growing, ecologically much suitable, pest and disease resistant tree species and also require less maintenance should be given top priority Columnar and medium-sized trees are preferred Ingold reported that the leaves with complex shapes and large circumference area reported to be collected particles more efficiently. Many trees like Neem (*Azadirchta indica*), Silk cotton (*Bombax ceiba*), Indian laburnum (*Cassia fistula and C. siamea*), Gulmohar (*Delonix regia*), Pipal (*Ficus religioso*), Jacaranda (*Jacaranda mimosifolia*), Indian lilac (*Lagerstroemia indica*), Temple or Pagoda tree (*Plumeria rubra and F. alba*), Java plum (*Syzygium cumini*) and several other roadside and street trees have found more suitable in urban environment. If such trees are to be planted, their local ecological relationship with human environment has to be studied properly. It should be borne in mind that these trees may cause allergic disorders such as hay fever; asthma and toxemia due to airborne pollen grains, which can also contribute to atmospheric pollution significantly(Bernably, A. 1978). Chakre has suggested that the insect-pollinated trees with short flowering periods and also with less pollen productivity should be selected. It is also recommended that wind-pollinated tree species those, flowering during rainy season can also be planted, as rains will wash out extra pollens A tree should be relatively free of insects and diseases and there should not be dropping of messy fruits (*Muntingia calabura, Cerbera odolam*), seed pods (*Acacia auriculaeformis*), twigs and leaves (*Dyera costulata*). Trees with a tendency to drop large and heavy fruits (Durio spp.) and emit bad smell (*Sterculia foetida*) must be considered a serious drawback(Dochinger, LS 1973).

Water pollution :-

Water has such a strong tendency to dissolve other substances and sometimes referred to as the universal solvent. This is largely because of its polar molecular structure. Pure water, that is, pure H20, is not found under natural conditions in streams, lakes, ground water, or the oceans. It always has something dissolved or suspended in it. Because of this, there is not any definite line of demarcation between clean water and contaminated water n general terms, water is considered to be polluted when it contains enough foreign material to render it unfit for specific beneficial use, such as for drinking, recreation, or fish propagation. Actually human activity is the cause of the poor water quality and cause water pollution.

Vegetative filter strips for water pollution control in agriculture :

Orchards, vineyards, and row crops have the greatest erosion rates in irrigated agriculture, especially those that are managed with hare soil between tree or vine rows. The vegetative filter strip (VFS) offers one way to control erosion rates and keep soil in the field rather than letting it be carried off site in drainage water(Shaw, G, and JN.B. Bell. 1991). A VFS is an area of vegetation that is planted intentionally to help remove sediment and other pollutants from runoff water.

Key design elements for vegetative filter strips :-

The United States Environmental Protection Agency (EPA) encourages growers to use engineered vegetative treatment systems such as VFSs at sites where these systems are likely to bring about a significant reduction in nonpoint source (NPS) pollution. You can establish VFSs downslope from crop fields or animal production sites to control NPS pollutants that would otherwise escape with runoff. In orchards, you can use multiple VFSs installed perpendicular to the direction of surface water runoff to reduce soil erosion and even avoid expenses associated with herbicide application. The strips also have the potential to reduce the level of some pesticides in runoff by enhancing water infiltration and retention in the field. For example, contaminants such as phosphorus and certain pesticides such as pyrethroids that bind strongly to soil particles get trapped and retained in VFSs

Pollutant-filtering mechanisms of vegetative filter strips :

1. A vegetative filter strip functionally consists of three distinct layers surface vegetation, root zone, and subsoil horizon and as a result, the flow of water and pollutants through the filter strip can be a complex process. Once surface flow enters a VFS, infiltration is followed by saturation of the shallow subsurface When the inflow rate exceeds the strip's infiltration capacity, overland flow occurs. In the root zone, some water infiltrates deeper into the subsoil while the remainder becomes lateral subsurface flow or interflow. Runoff is less from hill slopes that have VFSs than from those that have none, a result of increased infiltration rates in the vegetated area The vegetative strip's root zone allows high infiltration rates via macropores that arise with the generally improved soil structure created by plant roots and other biological activities. The most important pollutant-trapping mechanism of VFSs is infiltration, followed by storage in the surface layer(Oommanchan,1977). The soil constituent with the greatest influence on pesticide transport or pollutant retention and degradation is organic matter in the root zone and overlying surface litter layer Greater biological activity in a soil improves its ability to effectively deals with pesticides and pollutants, and that kind of activity ctivity is more prevalent in a soil rich in plant roots, soil micro- and macro-fauna, and bacteria than in a soil without those organisms. Soil microorganisms play an essential role in the degradation of contaminants and soil organic matter is chemically reactive with the contaminants. For these reasons, you can expect degradation and adsorption of herbicides and pesticides to be greater in the filter strip's root zone than in adjacent fallow soils. Vegetative filter strips on sloping land are subject to horizontal interflow within the root zone, in which case some pesticides may be filtered out, adsorbing onto soil organic matter. When the interflow water reappears on the surface as return flow it may have a lower pesticide concentration than the water that has flowed above ground. When. infiltration is high in a VFS, the microbial-and plant-uptake processes cause denitrification, degradation

of chemicals, and reduction of chemical concentrations in the surface layer between runoff events. The effectiveness of VFSs depends on field conditions such as soil type, rainfall intensity, slope, micro- topography (surface soil roughness), the infiltration capacity of the vegetated area, the width of the strip, and the height of its plants Slope and micro-topography affect overland flow velocity and uniformity and also appear to have an effect on the ability of VFSs to retain sediment and pollutants in runoff(Maheshwari, J. K 1963).

). Of course, the steeper the slope, the greater the sediment yield, all other factors heing equal. Infiltration capacity and interflow within the VFSs influence the fate and path of dissolved nutrients and chemicals. The width of VFSs determines the strips sediment removing capacity and the amount of time the pollutant can be expected to remain in soil layers where adsorption and degradation processes are active.

Aquatic plants for removal of pollutants (Pb, Cu, Cd, Fe, hg and chromium) from leather industries -:

Hydrilla verticillata, Spirodela polyrrhiza; Bacopa monnierii, Phragmites karka; Scirpus lacustris; Water hyacinth (Eichhornia crassipes); Pennywarth (Hydrocotyle umbellate; Duck weed (Lemna minor; Water velvet (*Azolla pinnata*).

Soil pollution :-

The introduction of substances, biological organisms, or energy into the soil, resulting in a change of the soil quality, which is likely to affect the normal use of the soil or endangering public health and the living environment.

Phytoremediation :-

Phytoremediation is the use of living green plants for in situ risk reduction and/or removal of contaminants from contaminated soil, water, sediments, and air. Specially selected or engineered plants are used in the process Risk reduction can be through a process of removal, degradation of, or containment of a contaminant or a combination of any of these factors. Phytoremediation is an energy efficient, aesthically pleasing method of remediating sites with low to moderate levels of contamination and it can be used in conjuction with other more traditional remedial methods as a finishing step to the remedial process(CPCR. 2006).

One of the main advantages of phytoremediation is that of its relatively low cost compared to other remedial methods such as excavation. The cost of phytoremediation has been estimated as $25-$100 per ton of soil, and $0.60-$6.00 per 1000 gallons of polluted water with remediation of organics being cheaper than remediation of metals. In many cases phytoremediation has been found to be less than half the price of alternative methods. Phytoremediation also offers a permanent in situ remediation rather than simply translocating the problem.

METHODS OF PHYTOREMEDIATION :-

Phytoextraction (Phytoaccumulation) :-

Phytoextraction, the use of plants to remove contaminants from soil by accumulation of contaminants in plant tissue, is a promising cleanup technology for a variety of metal-containing soils. However, hytoextrac-uption of high specific activity radionuclides such as 137Cs or 90Sr is a challenge because of the very low

molar reconcentrations of the radionuclide in soil (typically in weapthe order of 10.12 mol/kg) compared with much higher effecconcentrations of stable elements naturally present in soil in addition, plant uptake of 137Cs and 90Sr can be inhibited by competition with K and Ca, respectively. Further, the pros-pect of phytoextraction of 137Cs from contaminated soil is minimized because sorption of Cs into interlayer spaces on mica-illite minerals appears to be highly spe-cific and poorly reversible. Many metals such as Zn, Mn, Ni, and Cu are essential micronutrients. In common nonaccumulator plants, accumulation of these micronutrients does not exceed their metabolic needs (<10ppm). In contrast, metal hyper accumulator plants can accumulate exceptionally high amounts of metals (in the thousands of ppm). Hyper accumulator plants do not only accumulate high levels of essential micronutrients, but can absorb significant amounts of nonessential metals, such as Cd. Heavy metal absorption is governed by soil characteristics such as pH and organic matter content. Thus, high levels of heavy metals in the soil do not always indicate similar high concentrations in plants. The extent of accumulation and toxic level will depend on the plant and heavy metal species under observation. Most abandoned waste dump sites in many towns and villages in Nigeria attract people as fertile ground for cultivating varieties of crops. According to Alloway plants grown on soils contaminated with heavy metal concentration have increased heavy metal ion content due to pollution. The cultivated plants take up the metals either as mobile ions present in the soil solution through the roots or through foliar adsorption.

Rhizofiltration :-

Rhizofiltration is similar in concept to Phytoextraction but is concerned with the remediation of contaminated groundwater rather than the remediation of polluted soils. The contaminants are either adsorbed onto the root surface or are absorbed by the plant roots. Plants used for rhizoliltration are not planted directly in situ but are acclimated to the pollutant first. Plants are hydroponically grown in clean water rather than soil, until a large root system has developed. Once a large root system is in place the water supply is substituted for a polluted water supply to acclimatise the plant. Afer the plants become acclimatised they are planted in the polluted area where the roots uptake the polluted water and the contaminants along with it. As the roots become saturated they are harvested and disposed of safely. Repeated treatments of the site can reduce pollution to suitable levels as was exemplified in Chernobyl where sunflowers were grown in radioactively contaminated pools.

Phytostabilisation :-

Phytostabilisation is the use of certain plants to immobilize soil and water contaminants. Contaminant are absorbed and accumulated by roots, adsorbed onto the roots, or precipitated in the rhizosphere. This reduces or even prevents the mobility of the contaminants preventing migration into the groundwater or air, and also reduces the bioavailibility of the contaminant thus preventing spread through the food chain. This technique can also be used to re-establish a plant community on sites that have been denuded due to the high levels of metal contamination. Once a community of tolerant species has been established the potential for wind erosion (and thus spread of the pollutant) is reduced and leaching of the soil contaminants is also reduced.

Phytoremediation of organic polluted sites :-

Phytodegradation (Phytotransformation) :-

Phytodegradation is the degradation or breakdown of organic contaminants by internal and external metabolic processes driven by the plant. Ex planta metabolic processes hydrolyse organic compounds into smaller units that can be absorbed by the plant. Some contaminants can be absorbed by the plant and are then broken down by plant enzymes. These smaller pollutant molecules may then be used as metabolites by the plant as it grows, thus becoming incorporated into the plant tissues. Plant enzymes have been identified that breakdown ammunition wastes, chlorinated solvents such as TCE (Trichloroethane), and others which degrade organic herbicides.

Rhizodegradation :-

Rhizodegradation (also called enhanced rhizosphere biodegradation, phytostimulation, and plant assisted bioremediation) is the breakdown of organic contaminants in the soil by soil dwelling microbes which is enhanced by the rhizosphere's presence. Certain soil dwelling microbes digest organic pollutants such as fuels and solvents, producing harmless products through a process known as Bioremediation. Plant root exudates such as sugars, alcohols, and organic acids act as carbohydrate sources for the soil microflora and enhance microbial growth and activity. Some of these compound may also act as chemotactic signals for certain microbes. The plant roots also loosen the soil and transport water to the rhizosphere thus additionally enhancing microbial activity.

Phytovolatilization :-

Phytovolatilization is the process where plants uptake contaminaints which are water soluble and release them into the atmosphere as they transpire the water. The contaminant may become modified along the way, as the water travels along the plant's vascular system from the roots to the leaves, whereby the contaminants evaporate or volatilize into the air surrounding the plant. There are varying degrees of success with plants as phytovolatilizers with one study showing poplar trees to volatilize up to 90% of the TCE they absorb. Advantages of phytoremediation compared to classical remediation It is more economically viable using the same tools and supplies as agriculture It is less disruptive to the environment and does not involve waiting for new plant communities to recolonise the site Disposal sites are not needed.

- It is more likely to be accepted by the public as it is more aesthetically pleasing then traditonal methods.It avoids excavation and transport of polluted media thus reducing the risk of spreading the contamination.It has the potential to treat sites polluted with more than one type of pollutant.

Disadvantages of phytoremediation compared to classical remediation :-

- It is dependant on the growing conditions required by the plant (Le. climate, geology, altitude, temperature).Large scale operations require access to agricultural equpment and knowledge.
- Success is dependant on the tolerance of the plant to the pollutant.Contaminants collected in senescing tissues may be released back into the environment in autumn.Contaminants may be collected in woody tissues used as

fuel,Time taken to remediate sites far exceeds that of other technologies,Contaminant solubility may be increased leading to greater environmental damage and the possibility of leaching

CONCLUSION

Considering the present scenario of urban environmental pollution, there is a growing need for changing the approach of planting trees and other plant species. Inclusion of the ornamental plants having pollution mitigating ability in the landscape plan will serve the dual purpose of making the green and pollution free in the long run. Proper planting scheme will bring healthy life and colour in the cement concrete jungle of large congested cities. The importance of trees in urban environment is now widely recognized that they too cleanse the particulate air pollution and help to make cities and towns more agreeable places to dwell upon. India's rich biodiversity of both indigenous and exotic trees, offers a wide range of choice to restore our sick and sultry towns. The present paper recommends various tree species for urban plantings, so that a wider usage of local as well as exotic tree species can be explored for controlling airborne particulate pollution in urban climate. However, a basic knowledge of their biological relationship with human environment is absolutely necessary in which arboculturists, environmental scientists, and town planners can work together. Much more research on urban trees is needed for effective control of atmospheric particulate pollution.

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