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Various Methods of River Water Cleaning

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Abstract: 65% of the drinking water in our country comes from rivers and streams. Every year, millions of tonnes of trash find their way into the rivers and streams of our country. It can poison drinking water and endanger the lives of everyone who depends on it, making it more than simply an eyesore.In this paper we have discussed various methods of river cleaning to minimise water pollutants. We can effectively remove great quantities of physical waster through an unmanned river cleaning bot. Several effluents can be removed from river water is by the application of moving bed biofilm reactor and integrated fixed activated sludge. Another method is phytoremediation of contaminated waters using aquatic plants and artificial aeration. Due to its environmentally favourable characteristics, bioremediation (the use of microorganisms to clean up contaminated areas) has proven practical and trustworthy. Several variables, including but not limited to cost, site features, type, and concentration of contaminants, might determine whether bioremediation is done in situ or ex situ. The aim of this paper is to analyse and discuss the most efficient and effective methods of river water cleaning and decontamination.

Keywords: River Water Cleaning, Bioremediation, Phytoremediation, Unmanned River Cleaning Bot, Moving Bed Biofilm Reactor, Integrated Fixed Activated Sludge

I. INTRODUCTION

Due to the wide variety of contaminants that have an influence on freshwaters, there is an increased need for efficient treatment. Due to growing human activity on energy reserves, dangerous farming methods, and fast industrialisation, the level of pollution in the environment has been steadily rising over the last several decades. Heavy metals, radioactive wastes, pesticides, greenhouse gases, and hydrocarbons are some examples of the types of pollutants that cause issues for both the environment and public health owing to the toxicity they produce. The restoration of river ecosystems depends on the careful selection of technologies for treating river water in an acceptable manner. The purpose of this research was to conduct a comprehensive analysis of the various approaches to the treatment of river water.

II. REMOTE CONTROLLED UNMANNED CLEANING BOT

In general, the traditional approach is based on physical labour, and it is used for the collection of water debris, garbage, plastic, and any other kind of contaminant that is floating on water bodies or by collecting this contaminant using a boat, a thrash skimmer, or other similar ways and eliminated this contaminant from the area close to the river's edge before disposing of it.

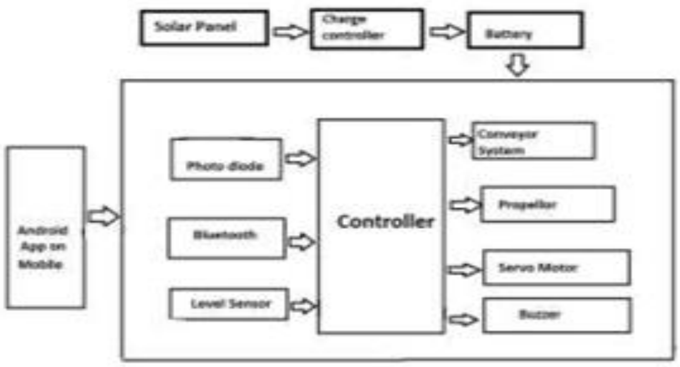

Figure 1. System Block Diagram [1]

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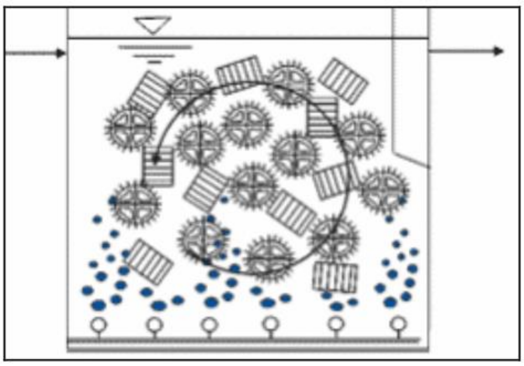
This traditional approach, on the other hand, calls for more labour, and as a result, it is often a strategy that is high in risk, expensive, and time consuming. When this factor is taken into consideration, all remotely controlled floating river cleaning equipment are more effective than traditional techniques. In addition, this solution is effective and beneficial to the environment. [1]

'Kumbh Mela' Because of the growing amount of water pollution, the government of India has taken it upon itself to clean rivers and ponds, and as a result, they have invested a significant amount of money in a number of river cleaning projects, such as "Namami Ganga" and "Narmada bachao." And also produced a large number of projects in a variety of places like as Ahmedabad and Varanasi, among others. This equipment for cleaning the river, which is controlled remotely, has been built with care given to the cleaning of the floating surfaces of rivers. Cleaning river floating surfaces with this Remote Controlled unmanned-Driver cleaning equipment was a concern taken into account throughout the machine's design process. Since technological advancement is occurring at a very quick rate in India, it is extremely necessary that any new gadgets that are put into use be kept up to date with the latest innovations on a consistent basis. In today's world, almost every gadget relies more on digital technology than analogue technology to perform its functions. Therefore, individuals working in the government cleaning industry may immediately begin using this bot in their cleaning duties. The practise of dumping garbage into nearby water bodies has become quite common in recent years due to the lack of garbage disposal facilities. This behaviour has the potential to have long-term negative effects not only on the biodiversity of the area but also on the environment of the surrounding area.Collecting garbage, plastic, and other floating waste and contaminants from water by hand or with equipment like boats and skimmer devices is a common example of the traditional approach.However, this traditional approach usually calls for more labour, which makes it riskier, more expensive, and more time consuming. Taking this into account, all floating, remotely controlled equipment for cleaning rivers are more effective and environmentally beneficial than traditional approaches. [1]

Due to a lack of proper waste management services, it is becoming common for people to dispose of trash in surrounding bodies of water. This has serious consequences for the local ecology and the local biodiversity. Solar panels are known to convert AC electrical energy into DC electrical energy. The DC output of the solar panels is pulsed and delivered directly into the charge controller, which in turn charges the battery with pure DC. The energy can be stored in a battery, as everyone knows. All of this circuitry receives its power from this stored energy. A controller, level sensor, photodiodes, Bluetooth, conveyor, propeller, buzzer, and servo motor are all part of this circuitry's extensive list of components. The controller plays a vital role in this setup, receiving input from components like photodiodes, Bluetooth, and level sensors and sending signals to things like a conveyor belt, a propeller, a buzzer, and a servo motor. The Android app serves as the universal remote control.[1]

III. MOVING BED BIOFILM REACTOR (MBBR)

For its low price, traditional activated sludge has been frequently employed as a biological treatment method in the past. Discharging treated wastewater into the natural water bodies now requires a lot of upgrades and adjustments to comply with stringent laws and regulations. As the world's population grows, the need for compact wastewater treatment facilities that can still generate a high-quality effluent while having a smaller footprint and producing less trash is rising. Biological processes, such as MBBR and IFAS, are an option for treating wastewater that may create high-quality effluent while yet maintaining a modest footprint.



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When it comes to aeration and reactors, MBBR systems rely on the specifically developed biological carriers to offer a surface for bacteria to colonise. Biofilm forms on the surface of suspended porous biofilm carriers with a density just below that of water when the carriers are continually mixed in an operational aeration tank, as shown in Figure 2. [2]

The MBBR system is an effective means of retaining biofilms composed of slow-growing microorganisms like nitrifies. Zimmerman (2005)'s field studies show that the MBBR process is adaptable and can be installed in tanks of varying sizes and shapes. The reactors are easy to set up and keep running, need simply a suitably sized tank and a series of reactors. The Wang (2006) study conducted an experiment on a smaller scale in the laboratory, utilising biofilm carriers with a filling ratio of fifty percent. The coagulant that was used was a solution of iron (II) sulphate in heptahydrate form. The effectiveness of MBBR was investigated using a DO concentration of 2 mg/L and a HRT of 6 hours. The amount of phosphorus that could be removed was determined to be more than 75%. It was determined that a removal effectiveness of 92% was the greatest possible. In the research carried out by Wang (2006), it was determined from the findings of the average concentrations of NH4+, NO3-, and NO2-, as well as their respective removal efficiencies, that the efficiency of nitrification could reach greater than 90% when the DO was maintained at a concentration of greater than 2 mg/L. In addition, it was reported that a DO of 2 mg/l may be used to achieve an average TN removal effectiveness of 89.9% from home wastewater. This was further stated. It has been hypothesised that the pace at which DO diffuses through the biofilm is the decisive factor in the process of medium nitrification. Previous research has shown that the moving bed biofilm reactor (MBBR) has established itself as a reliable and compact reactor for the treatment of wastewater. [2]

It has been established that the reactor is efficient in a wide variety of process combinations, not only for the removal of BOD but also for the removal of nutrients. The process's ability to fit into smaller spaces than activated sludge reactors is the key benefit it offers over other devices. Additionally, it does not call for the recirculation of sludge. Its adaptability is a benefit when compared to other biofilm processing methods, and more research on this bioreactor may provide other findings. However, each of the aforementioned approaches has some significant drawbacks that need to be considered. In addition, the majority of research done in the area of MBBR has solely concentrated on wastewater from home, industrial, and aquaculture sources. There has been no research done in the past that specifically focuses on numerous biological carriers, especially for the purpose of river water filtration, neither in a laboratory nor a pilot plant setting.[9]

IV. INTEGRATED FIXED ACTIVATED SLUDGE (IFAS)

Work on the IFAS application system started in the United States of America (USA) in the 1980s and 1990s, particularly focusing on the integration and modification of fixed film and activated sludge technologies. IFAS technology is being offered as an appealing solution for wastewater applications in proportion to the problems that exist now, such as increasingly rigorous effluent rules, the high cost of reactor tank enlargement, and lesser finance alternatives. Recent advancements in IFAS have brought to light a few benefits that come along with using this system. Even if it is supported by sedimentation tank, inadequate settling of biological solids is one of the most prevalent operational concerns in traditional activated sludge wastewater treatment systems across the globe. This problem occurs in systems all over the world. This may result in an increase in the cost of exclusive sludge treatment, as well as an increase in the concentration of TSS in the effluent and an increase in the dangers to downstream ecosystems and human health. However, according to the findings that were reported by Kim (2010), IFAS systems and non-IFAS systems were likely related to the observed differences in density and settle ability for the suspended phases. This is due to the fact that the stable and efficient removal of the biological solids produced in biological reactors is critical to the operation of biological wastewater treatment systems for the production of high quality effluent. [2]

The implementation of IFAS has gained significant recognition as a method that may reduce costs associated with the wastewater treatment process. On the other hand, little is known about the implementation, operation, and performance of such systems when they are used at large scale. It is very necessary to have an understanding of the experimental methods that was used in the past for providing comprehensive biological carrier support in MBBR and IFAS systems. It is essential that the approach be carried out on a laboratory basis if the goals of the research are to be attained. In order to conduct a successful laboratory experiment in water and wastewater treatment, there are a few considerations that must be made. The design Hydraulic Retention Time (HRT), reactor size, bio media size, kind of influent, and type of biological carrier are the critical aspects. [2]

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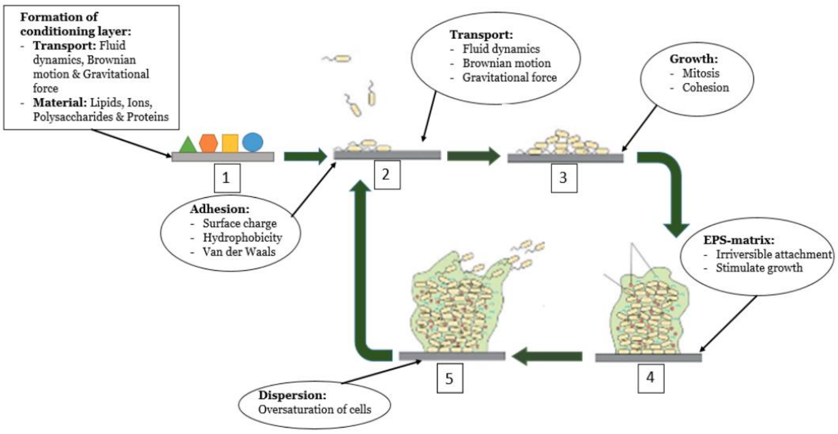

Figure 3. The five phenomena of biofilm development are shown graphically. The microorganisms' initial adhesion to the surface, their proliferation (or else micro-colony formation), and the maturation of the biofilm architecture with the presence of the polymeric matrix and its dispersion are all depicted in the figure, along with the conditions of the medium and the specific surface on which they occur. [11]Figure 2. Aerobic MBBR Reactor System [2}

According to research that was done in the past, integrated fixed-film activated sludge (IFAS) with a media of extruded high density polyethylene demonstrated higher removal efficiencies of 90%, 90%, and 85% for COD, TP, and ammonia, respectively, with a solids residence time (SRT) of 8 days. These figures were found for COD, TP, and ammonia. Recent research examined the effectiveness of a hybrid activated sludge/biofilm technique for the treatment of wastewater in a place with a cold environment. Plastic is often used as one of the materials that makes up the biofilm support medium for IFAS. They make use of a wide variety of plastics, the most common of which being polyethylene (PE) and polypropylene (PP). Nevertheless, each of the case studies that have been discussed up to this point has a number of significant limitations. There is a scarcity of data as well as inconsistency about the influence that IFAS systems have on the capacity of biomass to settle. The authors recommend that while developing an IFAS system, optimisation of the process for removing nutrients should be taken into account for achieving a good settling character. The possible impacts of IFAS on settle-ability in systems that do not remove nutrients need to be the focus of study that is carried out in the future. The kinds of bio media that are used in river water purification technologies may be classified by taking into consideration the different types of treatment systems. [3]

These bio media are now accessible on the local and worldwide markets for the water sector. Depending on the specific circumstances of the therapy, several kinds of bio media each have a performance that is unique to themselves. In addition to the bio media removal efficiency and the physical features at the designated design flow, other key elements that influence the choice in the selection of biological carriers for MBBR and IFAS include the frequency of maintenance and the cost. The bio media used in a river purification system need to be able to provide a suitable environment for the development of a layer of adherent microorganisms known as biofilm, which may be stationary or freely mobile within the system. According to the findings of earlier research, bio media used in MBBR and IFAS systems have only been extensively tested with household sewage or industrial wastewater, including wastewater from aquaculture. However, techniques of this sort bring with them a variety of drawbacks that are fairly well understood. There have been no controlled studies that assess the variations in physic-chemical and biological performance of bio media used in river water treatment plants under conditions typical of tropical rivers. On the other hand, the research that has been completed up to this point has been collated and published for the very first time in this article in order to get a greater perspective and understanding on the issue in the interest of conforming to the news approach. To achieve this objective, the most workable technological solution might be the coupling of an advanced biological process with bioreactor systems, such as a Moving Bed Biofilm Reactor (MBBR) and an Integrated Fixed Activated Sludge (IFAS) system.[2]

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V. Aquatic Phytoremediation

The term "aquatic phytoremediation" refers to a kind of phytotechnology that is utilised for the removal of contaminants from surface waters and the repair of water bodies that have been harmed (rivers, streams, lakes, ponds). Plants may be cultivated in surface waters to remove pollutants from both the water column and the sediment. These plants can then be deployed either at the point source of the pollution or inside waterbodies where diffuse pollution is an issue. In aquatic habitats, macrophytes, which include freshwater-adapted angiosperms, pteridophytes, and ferns, are the plants that are used during the process of aquatic phytoremediation. This helps remove and degrade contaminants. This definition does not include the many types of micro-algae. There are three basic growth types that may be used to broadly categorise macrophytes: floating, submerged, and emergent. Floating macrophytes are plants that live on the water's surface. These plants come from genera such as Lemna (duckweeds), Hyirocharis (frogbit), and Nymphaea (water lilies), and they may be free-floating or rooted. Submerged macrophytes grow largely below the water's surface and may be attached to the substrate. However, the genus Ceratophyllum, sometimes known as hornwort, is a common example of a submerged plant that does not have roots. Emergent macrophytes, such as Typha (reedmace) and Phragmites, are found around the edges of bodies of water. Although they have roots that extend into the substrate, the majority of their shoot development occurs above the water line (common reed). Depending on how these various kinds of growth are implemented, they either help remove contaminants from the water column or the sediment. Both of these environments include pollutants that need to be cleaned up. [12]

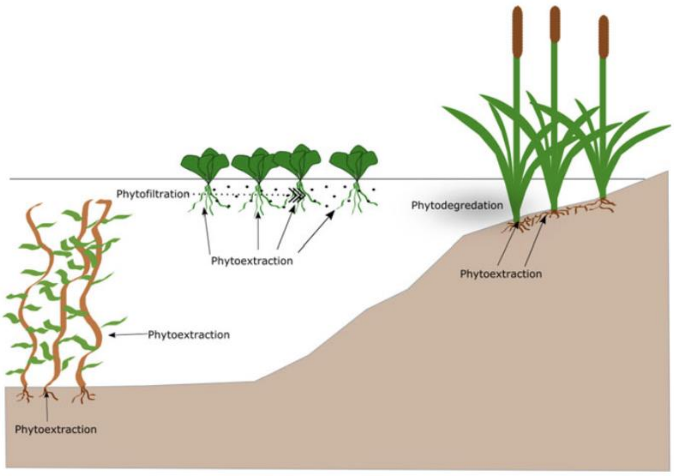

Figure 4. Types of plants that may be used in phytoremediation to reduce or eliminate contaminants in water. [4]

Macrophytes have a large potential for absorption of nutrients and other substances from their growth medium, and as a result, they may reduce the concentration of pollution in a target body of water. The primary methods of rhizo/phytofiltration, phytoextraction, phyto-volatilization, and phytodegradation are used by macrophytes in their ability to remove and breakdown contaminants. The roots of emergent and floating macrophytes are the primary organs responsible for the uptake of nutrients and other contaminants (whether from the substrate or the water column), whereas the stem tissue of submerged macrophytes may also play an important role in the removal of these substances from the water column. The specific mechanisms for pollutant removal and degradation by macrophytes are primarily determined by the type of pollutant (nutrient, heavy metals, organic pollutants, and biological) as well as the location of the pollutant within the surface water body (water column, lake or streambed sedi- ment). [13]

The practise of phytoremediation has traditionally been focused on optimising the effectiveness of water treatment; however, the advantages of phytoremediation in addition to those of remediation have, for the most part, been ignored. It is abundantly clear that water treatment is the major ecosystem service involved in the delivery of safe and clean water; yet, the introduction of new plant life into the environment results in the formation of new habitats for creatures. For instance, the inclusion of artificial floating islands increased the chick production of black-throated divers by 44% in waterbodies that had these structures. This indicates that FTWs may have a possible combined function in water treatment and better habitat connectivity. In a similar vein, a study that lasted for 15 years and investigated the environmental advantages of establishing treatment wetlands to ameliorate mine-tailing effluents discovered that there

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was a great richness and variety of protozoa, higher plants, terrestrial animals, and birds in the wetlands (Yang et al. 2006). [4]

In addition to the provision of habitat, there is also the possibility of supporting pollination and the storage of carbon. It's possible that the capacity for the latter will be determined by the post-remediation stage as well as the usage of the biomass. The enhancement of an area's visual appeal brought about by the addition of vegetation may also contribute to the provision of cultural services. This is especially likely to occur in urban waterways, where FTW has the potential to offer aesthetically pleasing green infrastructure. It is necessary to measure and evaluate the ecosystem services that are linked with phytoremediation projects in order to have a more comprehensive understanding of the many advantages that are produced by this kind of water treatment. There are new possibilities for the spatial flexibility and cost-effective application of phytoremediation as a result of the development of innovative methods to distribute macrophytes, such as via FTWs. These solutions are becoming available. In this regard, larger-scale pilot studies are necessary in order to evaluate the practical potential for use. At the moment, there is a large variety of macrophytes with a variety of growth types that have been identified as effective accumulators of pollutants. These macrophytes may be found all over the world. It is necessary to direct further attention on researching the potential for remediation offered by submerged species and identifying novel accumulators that may be used. It is important to note that several of the primary hyper-accumulators are considered invasive and would not be appropriate for use in natural surface waters if they were implemented there. Consideration of the advantages of a plant community-based approach that assembles polycultures of macrophytes with good accumulation capacity for various pollutants in order to enable multi-targeted remediation is a potential new development for phytoremediation systems. This is one of the proposed advancements for phytoremediation systems. In this situation, the necessity for the establishment of a rational method of macrophyte selection that is based on plant removal efficiency and environmental tolerances, as well as target pollutant standards, is required. [4]

The method of macrophyte phytoremediation still needs a more in-depth knowledge of how to improve removal efficiency and assure the harvesting of macrophytes in a sustainable manner. The removal of pollutants from water in a permanent manner and the preservation of the economic value of various PBRSs both need a comprehensive understanding of the spatial and temporal dynamics of pollutant translocation within macrophytes. In addition, a "metaorganism" approach has to be taken into consideration in future research on phytoremediation in order to determine the function of microbial communities that are connected with plants. It's possible that there are unrealised benefits to be gained by controlling these microbial ecosystems to improve performance.

In conclusion, the treatment of water has been the primary focus of phytoremediation, despite the increasing acknowledgment of the ability of ecological engineering solutions to offer ecosystem services such as carbon sequestration and the maintenance of biodiversity. In order to quantify the value that phytoremediation adds to a site, these advantages need to be measured more thoroughly. Composting, the generation of biofuels, and animal feed are examples of PBRSs that provide obvious potential for resource recovery as a result of the move in the waste management industry toward a life-cycle approach. In addition, there are other evident prospects for resource recovery. More research has to be done on these PBRSs to determine whether or not they are safe, whether or not they are valuable, and whether or not they may correlate directly with the pollutants that are being eliminated. In order to ensure that target pollutants are being considered in tandem with the PBRS and that the frequency of harvesting and replacement or regrowth of macrophytes is properly linked into the remediation of the target pollutant, prospective aquatic phytoremediation projects need to incorporate a life-cycle approach. [5]

VI. AERATION

Aeration, which raises the amount of oxygen that is dissolved in water, is an essential component in both the cleaning up of contaminated river water and the efficient treatment of waste water. Aeration plays an important role in the cleaning up of dirty river water as well as the efficient treatment of wastewater. Aeration methods are straightforward, easy to operate, environmentally friendly, and broadly applicable; nevertheless, their implementation may be costly. Aeration methods are straightforward, easy to operate, environmentally friendly, and widely applicable; however, their implementation can be costly. The cost of aeration might be high, but it is necessary to improve the variety and number of microorganisms present. A greater variety and richness of microbial populations, which are responsible for degrading organic compounds found in river water and wastewater, may be achieved by aeration. However, its effectiveness is contingent on the pace of aeration as well as the method of aeration approach, such as mobile or fixed point aeration (moving from one point to another). Because of this, it has to be adequately aerated as well as mobile aerated (moving from one point to another). For the treatment of water contaminated with sediment, one approach that should be used is called fixed-point aeration.

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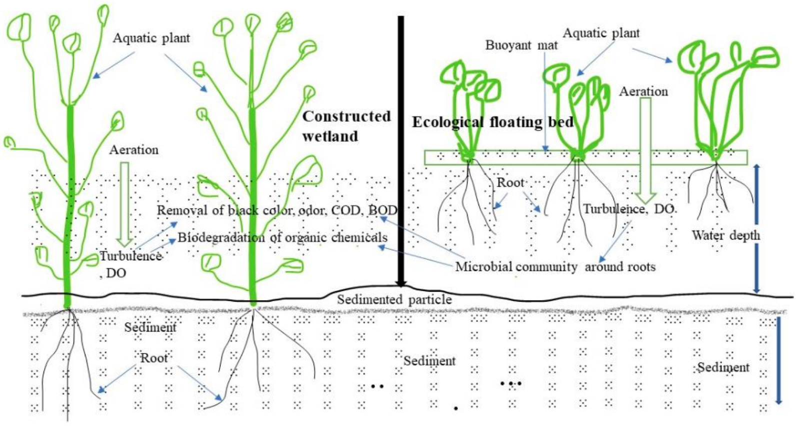

Figure 5. Ecological aeration of river water: a schematic representation. [6]

For instance, in the case of a sediment-rooted built wetland, fixed-point aeration should be employed, however movable aeration should be used when it comes to floating bed wetland approaches. Several earlier studies have shown that the use of aeration techniques effectively improves the water quality of some rivers, such as the Oeiras River in Portugal, the Emsche River in Germany, the Thames River in the United Kingdom, and the Homewood Canal in the United States. Aeration techniques also remove the black colour in Germany, the Thames River in the United Kingdom, and the Homewood Canal in the United States. Aeration techniques also remove the odour, COD, and BOD of river water in Busan. [6]

Experience has shown that in the past, in the present, and in what is likely to be the foreseeable future, the primary function of wastewater purification from organic and biogenic elements is performed by an aeration tank (an artificial biological treatment plant) equipped with an aeration system. This holds true for both the immediate past and the immediate present as well as the immediate future. The cost of aerating the sludge mixture in aeration tanks is estimated to account for between 60 and 80 percent of the total operating expenses of treatment facilities, according to the opinions of various experts. [14]

Energy indicators and 74tilized74 capacity are used to evaluate the effectiveness of various aeration devices. Oxidising capacity describes the quantity of dissolved oxygen that is produced in the air per unit of liquid over the course of one hour. The effectiveness of aeration facilities may be evaluated using one of the energy indicators, such as the amount of air required for the treatment of one cubic metre of waste water. This indicator is dependent on the efficiency with which air is supplied to the aeration tank, as well as the distribution of air inside the tank and the mixing of air within the tank. This efficiency is in turn dependent on the kind of aerator and the aeration system. The selection of an aerator is based on a comparison of many indicators, including aeration effectiveness and the 74tilized74 capacity of aerators. In addition, the construction and operation of mechanical aeration systems are quite straightforward, and they have a high 74tilized74 capacity with a low power need (1.35-1.4 kWh for decreasing of 1 kg biological oxygen demand in 5 days). In spite of these benefits, however, mechanical aerators suffer from a low level of operation reliability, and in the event that there is a significant amount of wastewater, a greater number of aerators are required. Furthermore, the working body of a mechanical aerator is made of metal, which is prone to breaking easily. If the depth of the tank is more than two metres, it may be difficult to stir the water. [15]

In addition, there are aerators that are of the airlift or jet kind. Among these, we can single out pneumatic aeration systems that work in a designated volume with pumping liquid (airlifts) and systems that stir water as some of the most notable examples (static aerators). During the functioning of these devices, the energy that is contained inside the compressed air that is provided to the aeration tank is used. Because of the possibility of aerators being clogged with salt deposits or oil pollution when pneumatic systems are used, aerators in the chemical, food, and petrochemical sectors often use these types of aerators instead. In the operation of heavily loaded sewage treatment facilities, jet-type aeration is also 74tilized as an additional means of aerating the water in the treatment process. On the other hand, jet-type aerators are more effective than medium-bubble aerators, despite the fact that they are less effective than fine-bubble aerators. Aerators of the jet-type are highly effective, holding a position that is somewhere between that of fine- and medium-bubble aerators in terms of effectiveness. In addition, activated sludge may be recirculated in a nitrifier by the use of jet-type aerators. It is helpful to avoid using pumps. The formation of tiny mono-bubbles is made more

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difficult when traditional bubblers are used in the construction of jet-type aerators. As a result, the efficiency of water saturation with ambient oxygen is reduced. Another notable drawback of jet-type aeration is that it necessitates the installation of blowing apparatus, which may be expensive. [7]

VII. BIOREMEDIATION

In the last twenty years, there have been substantial advancements in bioremediation methods, the ultimate objective of which is to efficiently recover damaged habitats in a way that is eco friendly, and at a cost that is extremely low. Researchers have created and modelled a variety of various bioremediation techniques; nevertheless, according to the nature and/or kind of pollutant, there is no one bioremediation strategy that functions as a "silver bullet" to repair damaged habitats. The autochthonous (indigenous) microorganisms that are already present in polluted environments hold the key to solving the majority of the problems that are associated with the biodegradation and bioremediation of polluting substances. This is provided that the environmental conditions are suitable for the growth and metabolism of the autochthonous microorganisms. In comparison to chemical and physical techniques of remediation, bioremediation offers a number of significant benefits, the most notable of which are its low cost and little impact on the surrounding environment. There have been a number of helpful definitions of bioremediation offered up to this point, with a specific focus placed on one of the processes (degradation). However, in some contexts, the terms biodegradation and bioremediation are used synonymously. The former is a phrase that refers to a process that falls under the latter. In the context of this discussion, the term "bioremediation" refers to a procedure that is based on the use of biological mechanisms to decrease (degrade, detoxify, mineralize, or transform) the concentration of pollutants to a benign condition. The process of pollutant removal is primarily determined by the nature of the pollutant, which can include agrochemicals, chlorinated compounds, dyes, greenhouse gases, heavy metals, hydrocarbons, nuclear waste, plastics, and sewage. Other types of pollutants that can be removed include greenhouse gases. It would seem that bioremediation strategies may be broken down into two categories, "ex situ" and "in situ," according on the location where they are applied. When deciding which bioremediation approach to use, some of the selection factors that are taken into consideration include the kind of pollutant, the level of pollution, the type of environment, the location, the cost, and any applicable environmental legislation. Prior to beginning a bioremediation project, major considerations are given not only to the selection criteria, but also to the performance criteria (which include oxygen and nutrient concentrations, temperature, pH, and other abiotic factors). These criteria determine the success of the bioremediation processes. In spite of the fact that there are a variety of bioremediation methods, the majority of bioremediation research is focused on hydrocarbons. This is because hydrocarbons are one of the most common types of pollutants that pollute soil and ground water. In addition, it is possible that other remediation methods, which may as well be more cost-effective and efficient to apply during the remediation process, are taken into consideration when it comes to the remediation of sites that are polluted with pollutants other than hydrocarbons. This is because other types of pollutants besides hydrocarbons can pollute sites. In addition, because of the nature of the activities that contribute to pollution caused by crude oil, it is expected that contamination of the environment caused by contaminants other than hydrocarbons may be readily avoided and regulated. In addition, the reliance on petroleum and other goods connected to it as primary sources of energy seems to have been a contributing factor in the rise in pollution brought on by this category of pollutants. [8]

From what has been discussed, it is obvious that bioremediation strategies are varied and have been shown to be efficient in repairing places contaminated by various contaminants. Bioremediation relies heavily on the action of microorganisms. Therefore, the fate of any bioremediation technique can be predicted with reasonable accuracy based on the diversity, abundance, and community structure of microorganisms in polluted environments, provided that other environmental factors that can inhibit microbial activities are maintained within an optimal range. Overcoming the constraints of microbial culture-dependent methodologies, molecular techniques such as "Omics" (genomics, metabolomics, proteomics, and transcriptomics) have led to a greater understanding of microbial identity, roles, and metabolic and catabolic path-ways. Pollutants may enter the food chain, preventing them from being broken down, and microbial populations might be low or nonexistent, all of which are impediments to success. [8]

Since microbiological activities are essential to bioremediation, bio-stimulation and bio-augmentation are the two main methods for boosting microbial activity in contaminated areas. Bio=stimulation is the process of supplementing a contaminated sample with nutrients or substrates to encourage the growth of native microorganisms. Since microorganisms are found everywhere, it stands to reason that pollution degraders are also prevalent in contaminated areas. Their population sizes and metabolic rates may change depending on the level of pollution in the environment.

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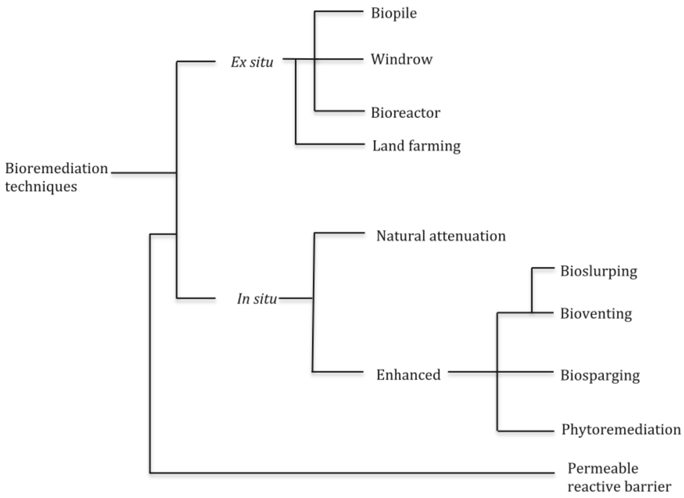

Figure 6. Biological methods of waste cleanup. It is not the sequence of progression from left to right of internal nodes, since the divergence of each approach is fictitious (technique development). The permeability of a reactive barrier is not the starting point. The early potential divergence may be attributed to the fact that this method is a physical remediation approach that incorporates aspects of bioremediation.[8]

Therefore, the difficulty of nutrient restriction in most contaminated areas may be overcome by the use of agro-industrial wastes with an acceptable nutritional composition, particularly nitrogen, phosphorous, and potassium. Although it has been observed that an excessive use of stimulants might reduce metabolic activity and variety in microorganisms, this is not the case here. However, bio-augmentation is a crucial strategy for introducing or expanding populations of microorganisms with degradation capabilities. It has been shown that groups of microbes work better together to break down contaminants than single species. This is because the metabolic differences between the isolates, which may have resulted from the isolation process, the adaptation, or the pollutant composition, may result in synergistic effects, which may lead to the full and fast destruction of pollutants when the isolates are combined (Bhattacharya et al. 2015). Polyaromatic hydrocarbons (PAHs) and other pollutants were removed from highly contaminated samples with greater efficiency using either bio-augmentation or bio-stimulation, as reported by Sun et al. (2012) as compared to a non-amended setup (control). However, it was shown that bio-stimulation was more successful in removing low molecular weight (LMW) PAHs and contributed to a larger proportion (33.9%) of total PAH removal compared to the 26.8% achieved with bio-augmentation. While bio-stimulation was able to remove a maximum of 10.85% of high molecular weight PAHs (4-6 ring-PAHs), bio-augmentation was found to remove 22% of HMW-PAHs from the contaminated sample used in the pilot research. Combining the two methods yielded the greatest decrease in LMW and HMW-PAHs (43.9 and 55.0%, respectively), as predicted. Accordingly, it seems that including bacteria with unique degradative capacities while feeding local microbes with nutrients may be more effective than depending on a single technique alone in the removal of HMW-PAHs, which are of public health concern in a polluted environment. [8]

However, there are still risks associated with bio-augmentation, including the introduction of pathogenic species, competition between native and non-native microbial populations, and the eventual extinction of the injected organisms. The viability of the microorganisms being augmented is very questionable in light of the fact that they may not be able to adapt to their new surroundings. Some of the problems with bio-augmentation may be alleviated by the use of carrier materials such agar, agarose, alginate, gelatin, gellan gum, and poly-urethane. Another potential strategy for cleaning up phenanthrene contamination is the use of microbial fuel cells (MFCs) with added inocula. Fodelianakis further said that native bacteria in polluted areas are likely superior than allochthonous microbes at degrading pollutants under ideal environmental circumstances. In ageing and poly-aromatic hydrocarbon contaminated settings, in particular, surfactants are often utilised to stimulate desorption and solubilisation of pollutants, hence enhancing mass transfer, and thereby increasing pollutant availability to degrading bacteria. Bio-surfactants are favoured over their chemical

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equivalents because of their low environmental impact and rapid decomposition. Large-scale deployment of bio-surfactants to contaminated locations is unfeasible because of high manufacturing costs and poor scalability. There is a possibility that bio-surfactant production may increase if agro-industrial wastes were employed as a food source during fermentation. [8]

Using various bioremediation methods at once during remediation will boost efficiency (by compensating for the limitations of individual methods) and reduce costs. A useful indication of biodegradation performance may be obtained by the use of integrated metrics of spatial configuration of networks of bacterial dispersion. The managed use of GEM has the potential to increase the efficiency of bioremediation processes. This is because it is theoretically possible to create a designer biocatalyst (GEM) capable of efficiently degrading a target pollutant, including recalcitrant compounds, by incorporating novel and efficient metabolic pathways, expanding the substrate range of existing pathway ways, and enhancing the stability of catabolic activity. However, this intriguing technique is hindered by issues including horizontal gene transfer and the unchecked proliferation of GEM in the environment. However, public acceptability of employing GEM to rehabilitate contaminated surroundings will be aided by the use of bacterial confinement systems, in which any GEM escaping an environment will be destroyed by the introduction of controlled suicide mechanisms. To further expand on this idea, a synthetic biology method to designing microbes with the degradative route of a specific molecule might boost bioremediation effectiveness. Nanotechnology has the potential to lessen contaminants' effects on microorganisms. Accumulation of Nano materials. It therefore takes less time and money to clean up the region since the microbes can more easily break down the garbage and harmful elements. [16]

VII. CONCLUSION

All kinds of living forms depend on water as a vital medium to survive. Because of numerous anthropogenic activities, the water is continually polluted, which poses a direct threat to the survival of all living things. To stop this difficult scenario, the regulatory agencies and authorities need to act right away. The receiving river water becomes contaminated with nutrients, organic compounds, metals, and nano-materials as a result of the random discharge of treated and untreated solid and liquid wastes into water. For the treatment of contaminated river water, several physical, chemical, biological, ecological, and engineering solutions are available. According to the scenario evaluations, enhanced effluent treatment and flow enhancement are anticipated to significantly lower pollution levels in the river system. It is advised to use this dual approach to lessen pollutants and improve low flows. The validity of the selection method's use in other applications must also be established by additional study. It may be said that the procedures are appropriately applicable if the application is successful for different types of study.

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