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USING BIOABSORBENTS TO REDUCE RIVER WATER POLLUTION: A REVIEW

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ABSTRACT

In present scenario, the river water has become wastewater due to disposal of city waste through which it flows. Most of the existing wastewater treatment plants are getting overload because of unexpected rapid urbanization and due to change in life style of common man. With such a pitch dark future of fresh water we have to think out of the box for new, better and efficient treatment method. In the recent years biosorption have emerged as an economical and environmental friendly method for the decontamination of polluted water in which impurities sequestering by different parts of the cell can occur via various processes: complexation, chelation, coordination, ion exchange, precipitation, and reduction. Biosorption is a process with some unique characteristics. It can effectively sequester dissolved metals from very dilute complex solutions with high efficiency. This makes biosorption an ideal candidate for the treatment of high volume low concentration complex waste-waters..

The paper reviews the work carried out by different researchers about the topic and discusses the remedies in brief. The paper is a part of series of research papers under which the objectives stated below are studied and researched.

OBJECTIVES

I. To Positioning Point and Non-Point sources of pollution in river.
II. To take River water sampling at various contaminated sites and chemical characterization of collected samples
III. To Finalizing type and dosage of microorganisms for Biosorption
IV. To Monitoring of river water quality periodically

Key Words—**Biosorption, Phosphate, Nitrates and Mula River Pune.**

INTRODUCTION

The water problem is a global phenomenon, and is not restricted to any one nation. Water pollution has been the inevitable outcome of the human's powerful desire for betterment of living standards, through increasing efforts and activities manifesting as heavy industrialization and constant urbanization leading to progressive aquatic system pollution. Human being truly depend on renewable fresh water for drinking, irrigation of crops, and industrial uses as well for production, transportation, recreation and waste disposal. In many regions of the world, the amount and quality of water available to meet human needs are already limited. The gap between freshwater supply and demand will widen during the coming century because of climate change and increasing consumption of water and increasing population.

Out of all the total water on earth, salt water in oceans, seas and saline groundwater makeup about 97% of it. Only 2.5–2.75% is fresh water, including 1.75–2% frozen in glaciers, ice and snow, 0.7–0.8% as fresh groundwater and soil moisture, and less than 0.01% of it as surface water in lakes, swamps and rivers. Freshwater lakes contain about 87% of this fresh surface water. (U.S. Geological Survey, 2014)

In Indian at 1990, the total water withdrawal was estimated at 552 BM^3 i.e. 30 per cent of the country's renewable water resources (1869 BM^3). The contribution from surface water was 362 BM^3, while the groundwater withdrawal was estimated at 190 BM^3. Approximately 460 BM^3 was used for irrigation while 25 BM^3 was used for domestic needs. About 19 BM^3 and 15 BM^3 were used for energy and industrial purposes respectively. Currently, more than 80 per cent of the 750 BM^3 water used in India is for irrigation. The balance 20 per cent is used to meet domestic, energy, industrial and other requirements. Estimates indicate that by the year 2025, the total water demand of 1050 BM^3will be very close to the total utilizable water resources of 1,122 BM^3 in the country. Though projections are not available beyond 2025, it is evident that the country may have to face an acute water crisis unless clear and strategic measures are adopted now. India's population is around 1.21 billion as on 1st March, 2011. The population of India is expected to stabilize at around 1,640 million by the year 2050. As a result, gross per capita water availability will decline from 1,820 m^3/ yr in 2001 to as low as 1,140 m^3/yr in 2050. Total water requirement of the country for various activities in the year 2050 has been estimated to be 1,140 m^3/yr. This is significantly more than the current estimate of utilizable water resource.(Status of Water Quality in India, CPCB 2011)

LITERATURE REVIEW

BIOSORPTION METHOD

Regine & Vieir [24] has studied that solution to solve the water pollution problem by toxic heavy metal contamination resulting from humans technological activities has for long presented a challenge. Biosorption can be a part of the solution. Some types of biosorbents such as seaweeds, molds, yeasts, bacteria or crab shells are examples of biomass tested for metal Biosorption with very encouraging results. The uptake of heavy metals by biomass can in some cases reach up to 50% of the biomass dry weight. New biosorbents can be manipulated for better efficiency and multiple re-use to increase their economic attractiveness.

Tsezoset al [18] has investigated in this paper Biosorption defined as the selective sequestering of metal soluble species that result in the immobilization of the metals by microbial cells. Metal sequestering by different parts of the cell can occur via various processes: complexation, chelation, coordination, ion exchange, precipitation, reduction. Biosorption is a process with some unique characteristics. It can effectively sequester dissolved metals from very dilute complex solutions with high efficiency. This makes Biosorption an ideal candidate for the treatment of high volume low concentration complex waste-waters. Pilot applications have shown the limitations associated with inactive microbial biomass mainly due to the cost of formulating the biomass into an appropriate biosorbents material. Furthermore, the negative effect of co-ions in the solution on the uptake of the targeted metals by the immobilized microbial biomass, and the reduced resilience of the biological material, made recycling and reuse of the biosorbents even more difficult. However, in cases of metabolically active microbial cells, in biological reactors, Biosorption contributes as a parallel mechanism together with other metabolically mediated mechanisms such as bio-precipitation and bio-reduction. For this reason, Biosorption should always be taken into account as a metal immobilization process in every case of metal bearing water streams treatment technology based on the interactions of microbial cells with soluble metal species.

Ramachandraet al. [23] has found all details related to the Biosorption with each important detail related to the Mechanism of Biosorption. Heavy metal contamination exists in aqueous waste streams of many industries, such as metal plating facilities, mining operations, tanneries, etc. Some metals associated with these activities are cadmium, chromium, iron, nickel, lead and mercury. Heavy metals are not biodegradable and tend to accumulate in living organisms causing diseases and disorders. Many industries like dye industries, textile, paper and plastics use dyes in order to color their products and also consume substantial volumes of water. As a result they generate a considerable amount of colored wastewater. The presence of small amount of dyes (less than 1 ppm) is highly visible and undesirable. Many of these dyes are also toxic and even carcinogenic and pose a serious threat to living organisms. Hence, there is a need to treat the wastewaters containing toxic dyes and metals before they are discharged into the water bodies. Many physico-chemical methods like coagulation, flocculation, ion exchange, membrane separation, oxidation, etc are available for the treatment of heavy metals and dyes. Major drawbacks of these methods are high sludge production, handling and disposal problems, high cost, technical constraints, etc. This necessitates cost effective and environmentally sound techniques for treatment of wastewaters containing dyes and metals. During the 1970s, the increasing awareness and concern about the environment motivated research for new efficient technologies that would be capable of treating inexpensively, waste waters polluted by metals and dyes. This search brought Biosorption/adsorption to the foreground of scientific interest as a potential basis for the design of novel wastewater treatment processes. Several adsorbents are currently used which are by-products from agriculture and industries, which include seaweeds, molds, yeast, bacteria, crab shells, agricultural products such as wool, rice, straw, coconut husks, peat moss, exhausted coffee waste tea leaves, walnut skin, coconut fiber, etc. Adsorption/Biosorption using low cost adsorbents could be technically feasible and economically viable sustainable technology for the treatment of wastewater streams. Low cost adsorbents are nothing but materials that require little processing, are abundant in nature or is a byproduct or waste material from another industry.

Parket al. [12] has studied in this paper details about the past as well as current research on the Method of Biosorption. The discovery and further development of Biosorption phenomena provide a basis for a whole new technology aimed at the removal of various pollutants or the recovery of valuable resources from aqueous systems. Today, Biosorption is one of the main components of environmental and bio-resource technology. Since the status of scientific developsmeant of a technology can be reflected through analyses of the literatures pertaining to it, in this review, they qualitatively examine almost all aspects of Biosorption research. A range of subjects are covered, including the initial history, raw materials, mechanisms, instrumental tools, process factors, modification and immobilization methods, recovery and regeneration, continuous processes, commercial application, and modeling studies of Biosorption. Finally, we summarized the important considerations of the current research on Biosorption, as well as the suggestions for its future directions. We believe that this review will prove to be useful for scientists and engineers in the performance of their research into Biosorption.

Veglioet al. [14] Investigated information related to the processes has been proposed and discussed in this report. Four cases of copper Biosorption are here reported and discussed as examples of application: Biosorption of copper onto Sphaerotilusnatans, Rhizopusoligosporus, calcium alginate and olive mill residues (OMR) have been here described and discussed. Several empirical and semi-empirical models have been proposed and summarized, to consider the pH effect on the heavy metal up-take. The proposed models, originated from Langmuir isotherm, may be useful to fit experimental data avoiding pH control during Biosorption tests and simply monitoring its equilibrium value. The adsorption isotherms were built considering experimental procedures at constant pH (in standard manner) and in pH edge conditions. Both empirical and semi-empirical models were able to fit these experimental results. The pH-edge experimental procedure coupled with the proposed pH-related models is proposed as useful tools to investigate and model Biosorption processes with single heavy metals in solution.

Nour and Ghadir [20] have examined the details of micro-organism roll in biosorption. Presence of metal ions in aqueous solutions represents a major environmental problem. These inorganic species are persistent and non-biodegradable pollutants that should be eliminated from water. In the recent years Biosorption have emerged as an economical and environmental friendly method for the decontamination of polluted water. The present work represents a review of the recently published literature discussing the use of non-modified biosorbents for the removal of metal ions from aqueous solution. In this review the main classes of biomass materials used as biosorbents are discussed along with the principle factors affecting the Biosorption process such as: solution pH, biomass dose, metal ion concentration and contact time. The potential health and environmental hazards of metal ions in ad it on to the kinetic and isothermal models usually assessed to fit the Biosorption experimental data were also reviewed.

Whiteet al. [10] has researched multiplicity of physico-chemical and biological mechanisms for the determination of the removal of toxic metals, metalloids and radionuclide's from contaminated wastes. Physico-chemical mechanisms of removal, which may be encompassed by the general term "Biosorption", include adsorption, ion exchange and entrapment which are features of living and dea biomass as well s derived products. In living cells, Biosorption can be directly and indirectly influenced by metabolism. Metabolism-dependent mechanisms of metal removal which occur in living micro-organisms include metal removal which occur in living micro-organisms include metal precipitation as sulphides, Complexation by siderophores and other metabolites, sequestration by metal-binding proteins and peptides, transport and intracellular compartmentation. In addition, Transformations of metal species can occur resulting in oxidation, reduction or methylation. For metalloids such as selenium, two main transformation mechanisms are the reduction of oxyanions to elemental forms, and methylation to methylated derivatives which are volatilized. Such mechanisms are important components of natural biogeochemical cycles for metals and metalloids as well as being of potential application.

L. Babaket al. [17] has founded in this paper gives information of Biosorption capacity of metals copper, lead and zinc by Geobacillusthermodenitrificans and Geobacillusthermocatenulatus. Solution of each metal was mixed with dry biomass and incubated at room temperature. The supernatant was taken and used for complex metric titration. The sorption capacity for Cu^{2+} was highest when using 0.5 g·l−1 Geobacillusthermodenitrificans (57 ± 4 mg·g−1). The sorption capacity rapidly decreases with increased concentrations. Similarly for Zn^{2+} ions, the highest sorption capacity was for biomass concentration 0.5 g·l−1 (18 ± 3 mg·g−1) and slowly decreases. For Pb^{2+} ions, the decrease is almost linear to the biomass concentration 2 g·l−1, i.e. from 117 ± 13 mg·g−1 to 53 ± 3 mg·g−1.The sorption capacity of Cu^{2+} ions was highest at the lowest biomass concentration of Geobacillusthermocatenulatus (65 ± 3 mg.g−1), then it sharply decreased and at concentration of biomass of 1 g·l−1 did not changed. In the case of Zn^{2+} ions, we could seen a moderate drop with the increasing concentration with the range of 24 ± 3 to 12.3 ± 0.4 mg·g−1. For Pb^{2+} ions was the decrease slow, from 119 ± 8 mg·g−1 to 54 ± 4 mg·g−1.Affi nity of metals to bacteria was determined in the order Pb^{2+}> Cu^{2+} > Zn^{2+}. The results show, that Geobacillusthermocatenulatus has better sorption capabilities than Geobacillusthermodenitrificans.

PHOSPHATES AND NITRATE REMOVAL METHODS

Daset al. [19] has stuided inthis paper that industrial effluents loaded with heavy metals are a cause of hazards to human and other forms of life. Conventional methods such as precipitation, evaporation, electroplating, ion exchange, membrane processes, etc. used for removal of heavy metals from waste water however, are often cost prohibitive having inadequate efficiencies at low metal ion concentrations. Biosorption can be considered as an alternative technology which has been proved as more efficient and economical for removal of heavy metals from the industrial waste water. The most frequently used biosorbents are bacteria, fungi, algae and yeasts. But more recently, low cost natural products have also been searched as biosorbents. This paper presents an overview of the potential use of some natural products as biosorbents which could serve as a cost effective means of treating effluents charged with toxic heavy metals.

Fried et al. [25] has investigated high rates of agricultural runoff whichcan cause large quantities of nitrates and phosphates to enter the water system. When added to a water body, these nutrients can create a large proliferation of algae which is harmful to water quality. The blooms deplete oxygen levels in aquatic ecosystems and thus have a detrimental effect on the organisms within the system. We evaluated the effects of nine different combinations of nitrate and phosphate concentrations on algal growth by measuring relative chlorophyll levels. We concluded that both nitrates and phosphates have positive effects on algal growth. However, these variables affect algal growth independently of each other and there is no interaction between the two. This implies that both nitrates and phosphates are effective limiting nutrients that can be reduced to control algal proliferation.

O. Korostynskaet al. [21]has studied what consumers expect from water supply companies to deliver safe drinking water that meets both health quality standards and aesthetic requirements such as color, turbidity, taste and odor. Current water quality assessment methods of these parameters, which form the basis for sound water resources management, are mainly laboratory based, require fresh supply of chemicals, trained staff and are time consuming. Real-time water quality monitoring is essential for National and International Health and Safety, as it can significantly reduce the level of damage and also the cost to remedy the problem. This paper critically analyses both commercially available and state-of-the-art research methods and devices suitable for real-time wastewater quality monitoring and suggests further developments in this area. In particular, the focus is made on the monitoring of nitrates and phosphates in wastewater and a novel microwave based method for instantaneous water quality assessment is suggested

RIVER POLLUTION

Kanaseet al. [11] has carried out Physico-Chemical monitoring of major rivers in Pune was done during the month of June and July 2005. In Pune city, there are three major rivers named Mula, Mutha and Pavana. For this assessment, six sampling points were selected from Khadakwasla (Mutha River) to Sangavi (Pavana River) and the samples were collected along the course of rivers. The analysis was carried out for the parameters namely pH, Acidity, Alkalinity, Total hardness, Calcium, Magnesium, Chloride, Nitrate, Sulphate and Phosphate. In many into the rivers; which probably exceed the assimilative capacity of environment; leads to accumulation of pollutants on ground water and soils. The results obtained in this investigation revealed that the discharge of untreated industrial Effluents and sewage have contributed considerable pollution in the rivers Mula, Mutha and Pavana; hence the water of these rivers is unsafe for consumption or human use and needs preventive action.

Chandanshive [09] has found pollution status and impact on fish diversity in Mula-Mutha River and dams on it. Seventy-two were species reported in 1942 in this river. However, it has been observed that fish diversity is gradually decreasing since last thirty years unpresidenty, mainly due to manifold human activity. Fish diversity in midway of river is becoming rare and only four species have been reported form polluted stretch of river. The river Mula-Mutha is flowing through city area and is one of the important sources of water body because of seven dams on it and its importance in agricultural, industrial and development of Pune city. Its perennial nature supports abundance of aquatic life including fish fauna. About Sixty Three species of different fishes have been reported from upstream from January 2003- December -2007 and only four species of fishes in the downstream during winter and summer. The River Mula-Mutha and its tributaries are highly polluted due to domestic and industrial wastes. The physico-chemical aspects of water pollution of River Mula-Mutha were analyzed seasonally with respect to following parameters from July-2004 to May-2005. I) Water temperature, II) pH, III) Dissolved solids, IV) Dissolved oxygen, V) Free carbon dioxide, VI) Acidity, VII) Alkalinity, VIII) Chloride content, IX) Nitrates, X) Phosphates, XI) Biological oxygen demand, XII) Chemical oxygen demand. It is observed that the level of these parameters was optimum during and winter and summer seasons. In the polluted stretch of this river, tolerant species as Aorichthysseengala, Oreochromi, Smossambicus and Gambusiaaffinis as well as air breathing fish H. fossilisare found at many places.

CONCLUSION

The paper reviews the different views of researchers worked in past and working to minimize the pollution of river water by using different techniques like bioabsorption.

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