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Reduction of Heavy Metal and Hardness from Ground Water by Algae

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Abstract Phytoremediation is a novel technique that uses algae to clean up polluted water and soil. It takes advantage of the alga's natural ability to take up, accumulate and degrade the constituents that are present in their growth environment. Algae based waste water treatment systems offer more simple and economical technology as compared to the other environmental protection systems. Photosynthesis can be effectively exploited to generate oxygen from waste water remediation by algae. The choice of algae to be used in wastewater treatment is determined by their robustness against wastewater and by their efficiency to grow in and to take up nutrients from wastewater. By using Synechocystis salina almost 60% Cr, 66% Fe, 70% Ni, 77% Hg, 65% Ca^{2+}, 63% Mg^{2+} and 78% of total hardness was reduced in 15 days of treatment.

Keywords: *contaminates, dissolved, phytoremediation, pollution, water*

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1. Introduction

Many aquatic ecosystems have been subjected to industrial waste discharge. Domestic and agricultural pollution generating both organic and inorganic contamination, such as pesticides and heavy metals, are leading to widespread contamination of both surface and groundwater by runoff. Metals are introduced into the aquatic ecosystems as a result of weathering of soil and rocks, from volcanic eruptions and from a variety of human activities involving mining, processing and use of metals and/or substances containing metal contaminants [1]. These heavy metals may also be derived from remobilization from natural soils due to the changes in local redox conditions and the corrosion of subsurface engineering structures due to prolonged submergence under acidic groundwater [2]. Industrial activity has led to very high heavy metal concentrations on the environment, which are in general 100–1000 fold higher than those in the Earth's crust, and locally, living organisms can be exposed to even higher levels [3]. In a river polluted by base-metal mining, cadmium was the most mobile and potentially bioavailable metal and was primarily scavenged by non-detrital carbonate minerals, organic matter, and iron-manganese oxide minerals [4]. Although mercury is a naturally occurring element and it was always present in the environment, global human activity has led to a significant increase of mercury released into the atmosphere, aquatic environment and land [5]. The most important anthropogenic sources of mercury pollution in aquatic environment are atmospheric deposition, urban discharges, agricultural material runoff, mining, fossil fuel use and industrial discharges, burning of coal, and pharmaceutical production [6]. The trace elements may be immobilised within the stream sediments and thus could be involved in absorption, co precipitation, and complex formation [7]. Sometimes they are co-adsorbed with other elements as oxides, hydroxides of Fe, Mn, or may occur in particulate form. However, in order to control heavy metal levels before they are released into the environment, the treatment of the contaminated wastewaters is of great importance since heavy metal ions accumulate in living species with a permanent toxic and carcinogenic effect [8].

Hard water has high concentrations of Ca^{2+} and Mg^{2+} ions. Hardness is reported in terms of calcium carbonate and in units of milligrams per litre (mg/L). Hard water is generally not harmful to one's health but can pose serious problems in industrial settings, where water hardness is monitored to avoid costly breakdowns in boilers, cooling towers, and other equipment that handles water [9]. In domestic settings, the hardness of water is often indicated by the non-formation of suds when soap is agitated in the water sample. Hardness in water is defined as concentration of multivalent cations such as Ca^{2+} and Mg^{2+}. Hard water also forms deposits that clog plumbing. Calcium and magnesium carbonates tend to be deposited as off-white solids on the surfaces of pipes and the surfaces of heat exchangers. The term hardness total hardness is used to describe the combination of calcium and magnesium hardness. However, hardness values are usually quoted in terms of $CaCO_3$ because this is the most common cause of scaling [10].

Organic pollutants and heavy metals are considered to be a serious environmental problem for human health [11].

The contamination of soils and aquatic systems by toxic metals and organic pollutants has recently increased due to anthropogenic activity. Phytoremediation has emerged as the most desirable technology which uses plants for removal of environmental pollutants or detoxification to make them harmless [12]. Many living organisms can accumulate certain toxicants to body concentrations much higher than present in their environments [13]. Thus, the use of plants for the decontamination of heavy metals has attracted growing attention because of several problems associated with pollutant removal using conventional methods. Bioremediation strategies have been proposed as an attractive alternative owing to their low cost and high efficiency [14]. Recently, there has been a growing interest in using algae for biomonitoring eutrophication, organic and inorganic pollutants. The picture of the algae of different culture is shown in Figure 1.

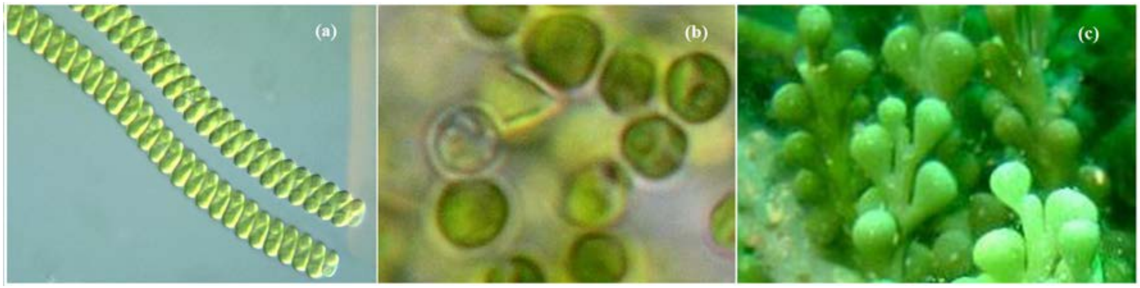

Figure 1. Different species of micro-algae

By using the chlorophyll formation of the algae, for example, it was possible to estimate spectrophotometrically the total nitrogen content in water collected from aquatic systems giving us an idea on eutrophication levels [15]. The plant used in the phytoremediation technique must have a considerable capacity of metal absorption, its accumulation and reducing the time of decontamination of an ecosystem [16]. Plants are known to be able to accumulate many heavy metals. Heavy metal tolerance in plants may be conferred by their immobilization in the cell wall, or by their compartmentalization in vacuoles. Some algae show a high capacity for accumulation of heavy metals as results of tolerance mechanisms and many algae synthesize phytochelatins and metallothioneins that can form complexes with heavy metals and translocate them into vacuoles. The main goal of study is to reduced the of heavy metal and compound present in the ground water. Through these work its try focus on the importance of natural treatment of waste water. The decrease in percentage component are studied by X-ray diffraction method

2. Material and Methods

2.1. Material

The micro algae *Synechocystis salina* gelatinosa were collected from local area detailed investigation on phycoremediation and removal of heavy metal and hardness from water sample. The synethic water was generated in labotary.

2.2. Method

The pilot sloping pond was constructed in RCC and was designed with a dimension of 268 cm. (Length) x 238 cm. (Width) x 64 cm. (Depth) with a sloping angle (made of GI sheet) of the evaporating surface at 150. The dimension of the sloped area was 2.53 m^2. The flow rate of the effluent was maintained at 59.6 L/day (litres per day). 1 cm of water in the tank equaled 63.7 L and the plant was run during the day for about 9 hrs.

2.3. Analysis

Heavy metal chromium (Cr), Iron (Fe), Nickel (Ni), Mercury (Hg), hardness Calcium carbonate (Ca^{2+}) and Magnesium carbonate (Mg^{2+}) were analyzed according to APHA Book [17].

3. Result and Discussion

3.1. Reduction of Heavy Metal

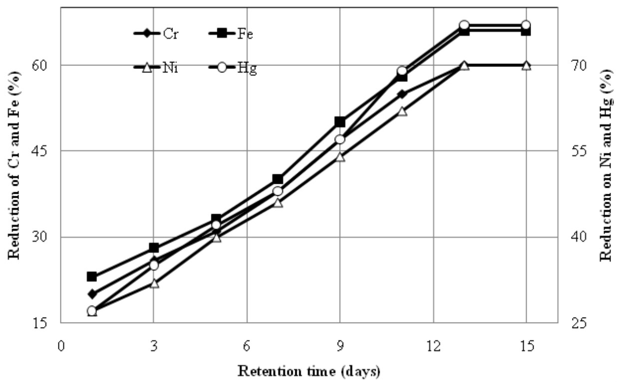

Figure 2. Effect of retention time on heavy metal reduction

The reduction of heavy metal was carried out for 15days for chromium (Cr), iron (Fe), nickel (Ni) and mercury (Hg), which shown in Figure 2. The maximum 60% Cr, 66% Fe, 70% Ni and 77% Hg was found at 13 days of treatment. The treatment efficiency was increase with increase with the retention time. For Cr 20, 26, 31, 38, 47, 55%, Fe 23, 28, 33, 40, 50, 58%, Ni 27, 32, 40, 46, 54, 62% and Hg 27, 35, 42, 48, 57, 69 respectively. These is might be due ability of algae to accumulate metals within their tissues has led to their widespread use as bio-monitors of metal availability in marine systems. These algae can be hyper-phytoremediators and their presence in water reduces water heavy metal. The principal mechanism of metallic cation sequestration involves the formation of complexes between a metal ion and functional groups on the surface or inside the porous structure of the biological material. The carboxyl groups of alginate play a major role in the complexation.

Different species of algae and the algae of the same species may have different adsorption capacity [18,19].

3.2. Reduction of Hardness

The reduction of temporary hardness and total hardness was carried for 15 days, which is shown in Figure 3. It was found that 65% of calcium and 63% of magnesium and 78% of total hardness was maximum at 13 days of experiment. The reduction was 9, 17, 27, 36, 45, 57% of calcium, 8, 16, 25, 34, 42, 55% of magnesium and 10, 21, 30, 42, 53, 65% total harness was observed for 1, 3, 5, 7, 9, and 11 days of treatment. These might be due to first they are oxidized to assimiable form before being too utilized by algae. Algae liberate no other gas oxygen during their exponential phase of growth [20,21,22].

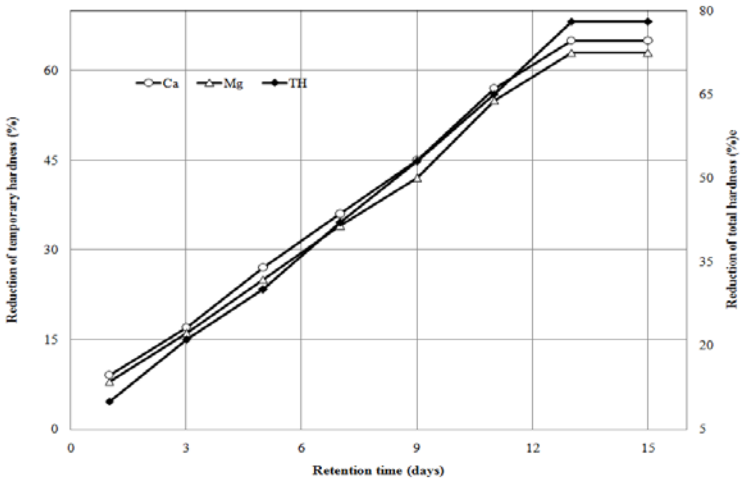

Figure 3. Effect of retention time on reduction of total hardness and temporary hardness

3.3. X-ray Diffraction Study

To determine the effect of reduction of heavy metal and hardness from the ground x-ray diffraction was studied, which is shown in Figure 4 and Figure 5. It was found that initially the Cr, Fe, Ni, and Hg was showing peaks in Figure 4(a) after treatment the peak was decrease in Figure 4(b). Similarly for the reduction of calcium and magnesium before treatment the peak are high in Figure 5(a) after treatment the peak was decrease Figure 5(b). From this was conclude that algae have been genetically engineered to remove a specific heavy metal from contaminated water by over expressing a heavy metal binding protein, such as metallothionein, along with a specific metal transport system [23,24].

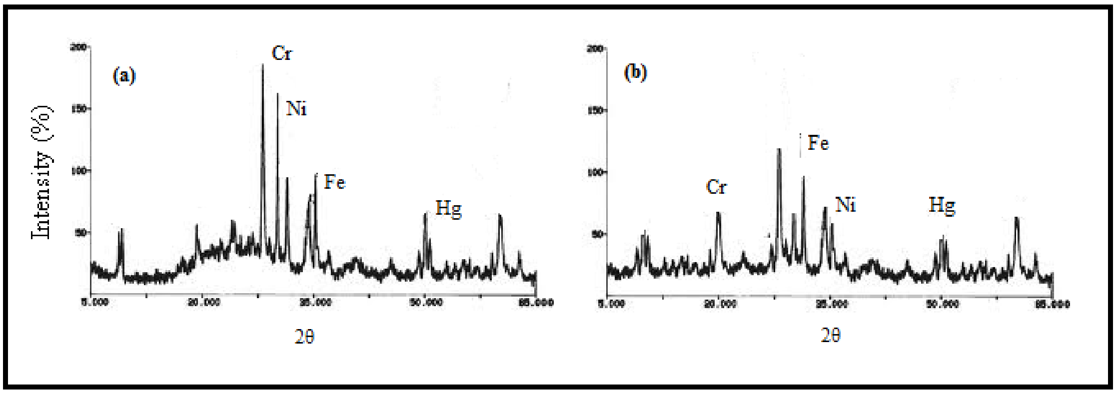

Figure 4. X-ray diffraction of heavy metal reduction studied (a) before treatment (b) after treatment

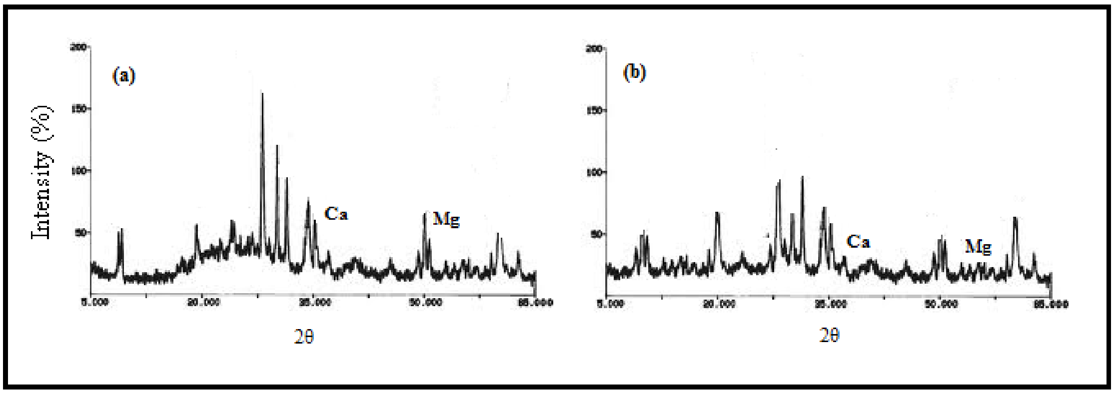

Figure 5. X-ray diffraction of hardness reduction studied (a) before treatment (b) after treatment

4. Conclusion

Stimulating the natural process of phycoremediation offers an opportunity for reducing the environmental impact of various pollutants. This forms an effective and economic biological treatment of polluted waters. Many micro and macro algae are being used in various bioremediation techniques especially in polluted waters. The intimate association which the algae have with the aquatic habitat makes them an interesting tool for such studies. By algae treatment method almost 60% Cr, 66% Fe, 70% Ni, 77% Hg, 65% Ca^{2+}, 63% Mg^{2+} and 78% of total hardness was reduced in 15 days of treatment. Removal rates of particularly high rate algal ponds are almost similar to conventional treatment methods but it is more efficient with lower retention time. With these specific features algal water treatment systems can be accepted as an significant low-cost alternatives to complex expensive treatment systems particularly for purification of municipal drinking waters.

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