

Rural Water Quality Monitoring and Exploring Low-Cost Treatment Technology with Water Hyacinth

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Abstract: Ground water in general is clean and fresh. However, industrialization and urbanization together with intensified agricultural activity have led to increasing demands on one hand but to the potential for large scale release of contaminants on the other. Water pollution disturbs the normal uses of water for agriculture, public water supply, aquatic life, wild life and industry. An understanding of the various types of pollutants is of considerable importance to the efficient management of water resources. Inorganic pollutants discharged into natural waters consist of mineral acids, inorganic salts, metal compounds, complexes of metal and trace elements. The proposed investigation will evaluate the underground water quality of hand pump water and Tap water of Sirgitti in rural area and its surrounding industrial areas near 7 km from Bilaspur C.G. With this objective in mind, A new and low-cost technology for purification of water by water hyacinth (*Eichhornia crassipes*), is a feasible solution. Water samples were collected during the growth of water hyacinth. Water purification with low-cost treatment technology using water hyacinth. The common Water Hyacinth is vigorous growers known to double its population in only 12 to 15 days. In the Water Hyacinth area and the nearby area, water pH showed a decrease between the August and September sampling followed by an upward trend and stayed stable around 9.3 in the far water hyacinth area. Water transparency showed a slow increase in August and September, and then a gradual decline in October; generally, transparency was significantly lower in the water hyacinth area than in other areas. Water Hyacinth has been used in aquatic systems worldwide for waste water purification. It has tremendous capacity of absorbing nutrients and other substances from the water and hence brings the pollution load down. In the present study an attempt was made to find the potential of Water Hyacinth in the treatment of Tap and hand pump water near industrial area of Sirgitti. The parameters studied were pH, EC, DO, BOD, TDS, Salinity, Alkalinity and Turbidity. Six months of experimental investigation showed that water hyacinth reduced considerably all the physicochemical parameters and but increased the Dissolved Oxygen (DO) to a significant level therefore it is concluded that Water Hyacinth (*Eichhornia crassipes*) is highly efficient in purification of water in respect of physicochemical parameters.

Keywords: Ground water, Industrialization and urbanization, Water pollution and Water hyacinth.

1. Introduction

Water is essential for everything on our planet to grow and prosper. Water that is free of disease-producing micro-organisms and chemical substances deleterious to health is called potable water. Water contaminated with either domestic or industrial wastes is called non potable or polluted water. The objectives of primary concern in providing potable water are freedom from harmful micro-organisms and freedom from undesirable or harmful chemicals. Although we as humans recognize this fact, we disregard it by polluting our rivers, lakes and oceans. Despite advances in drilling, irrigation and purification, the location, quality, quantity ownership and control of potable water remains an important human concern [1]. Water is said to be polluted when it is changed in its quality or composition directly or indirectly as a result of waste disposal and other human activities so that it becomes less suitable or harmful for drinking, domestic, agricultural, fisheries or other purposes. Temperature, turbidity and total suspended solids in underground water can be greatly affected by human activities such as agriculture, deforestation and the use of water for cooling.

For example, the upward trend in soil erosion and the related increase in total suspended solids in rivers can be seen in most of the mountainous regions in India. The release of untreated domestic or industrial wastes high in organic matter into rivers results in a marked decline in oxygen concentration and a rise in ammonia and nitrogen concentrations, downstream of the effluent input. Industrial activities which discharge large organic loads include, pulp and paper production and food processing. Uncontrollable discharge of industrial waste water often causes pollution due to toxic metals [2].

Other sources of metal pollution are leachates from urban solid waste landfills and mining waste dumps. Increased mineral salts in rivers may arise from pollution by mining and industrial waste waters. Under certain hydrogeological conditions, unsewered domestic waste can cause severe ground water contamination by pathogenic bacteria, nitrate and other pollutants. Pumping of industrial waste water into ground water has resulted in high nitrate, arsenic and iron content [3]. All-natural waters contain dissolved inorganic and organic substances.

In natural surface water, the major dissolved solids are calcium, magnesium, sodium, potassium sulphates, carbonates, bicarbonates, chloride and silica. Many pollutants may also be found in solution form in water. These may be phosphates, fluorides, nitrates and certain metals or may be unnatural materials such as pesticides [4]. Many causes of pollution including sewage and

fertilizers contain nutrients such as nitrates and phosphates. In excess levels, nutrients over stimulate the growth of aquatic plants and algae. Excessive growth of these types of organisms consequently clogs our water ways, use up dissolved oxygen as they decompose, and block light to deeper waters. This in turn proves very harmful to aquatic organisms as it affects the respiration ability of fish and other invertebrates that reside in water.

Pollution is also caused when slit and other suspended solids, such as soil, wash off plowed fields, construction and logging sites. Pollution in the form of organic material enters waterways in many different forms as sewage, as leaves or as runoff from live-stock feedlots and pastures. Pathogens including bacteria, viruses and protozoan enter waterways through untreated sewage, storm, drains and septic tanks [5]. Heat is a pollutant because increase in temperature results in death of many aquatic organisms. Heated waters reduce the amount of dissolved oxygen content which degrades organic matter at a faster rate. Thus, we can conclude that there exist two types of water pollutants: point source and non-point source.

Point sources of pollution occur when harmful substances are emitted directly into a body of water. A non-point source delivers pollutants indirectly through environmental changes [6]. Water hyacinth is a permanent, marine plant, free floating perennial herb for fresh water ecosystem or anchor in low water. It is frequently appeared at the surface of rivers, lakes, canals and ponds and may root in the mud of shallow waters. It is a noxious weed that has attracted worldwide attention due to its fast spread and growth, which lead to serious problems in navigation, irrigation, and power generation. Water Hyacinth which is native to the Amazon basin, Brazil became widespread throughout the world, also due to its attractive appearance. It is commercially available as an ornamental for ponds.

Its spread started with its deliberate introduction into North America from Brazil, in the late nineteenth century, as an ornamental in ponds and subsequently escaped cultivation. At present it occurs as a weed throughout tropical and subtropical regions of the world. Water hyacinth is free floating aquatic plants in which roots play important role in removing nutrients [7]. It has tremendous capacity of absorbing nutrients and other substance from water [8] and hence brings the pollution load down. It is found to be most effective in removal of BOD, suspended solids, and heavy metals etc. from waste water [9]. The plant is extremely tolerant and has a high capacity for the uptake of heavy metals, including Cd, Cr, Co, Ni, Pb and Hg, which could make it suitable for the bio-cleaning of industrial wastewater. In addition to heavy metals, Water hyacinth can also remove other toxins, such as cyanide. It can remove arsenic from arsenic contaminated drinking water. It may be a useful tool for removal of toxic metals as it can soak up soluble heavy metal ions.



Figure 1.
Root of water hyacinth plant.

2. Methods and Materials

Ground water is the major source of drinking water in both urban and rural India. Besides, it is an important source of water for the agricultural and the industrial sector. Being an important and integral part of the hydrological cycle, its availability depends on the rainfall and recharge conditions. India is heading towards a fresh water crisis mainly due to improper management of water resources and environmental degradation, which has led to lack of access to safe water supply to millions of people. Ground water crisis is not the result of natural factors; it has been caused by human actions. During the past two decades, the water level in several parts of the country has been falling rapidly due to increase in extraction. Intense competition among users agriculture, industry and domestic sectors is driving the ground water table lower.

The quality of ground water is getting severely affected because of the widespread pollution of surface water. Besides, discharge of untreated waste water through bores and leachate from unscientific disposal of solid wastes also contaminates ground water. Physico-chemical analysis is the prime consideration to assess the quality of water for its best usage, say for drinking, bathing, fishing, industrial processing, etc. It is also essential to know the pollution strength of waste water either domestic or industrial. Although a large number of studies have been done on using the stems and leaves of water hyacinth as absorbent, there are several interesting and novel applications of water hyacinth. For example, water hyacinth has been demonstrated to be useful to develop super capacitors, for production of ethanol, and to improve the immune resistance of plants and animals [10].

3. Experimental Plan

The experiment was performed in the Department of Chemistry, D. P. Vipra College, Bilaspur, in Chhattisgarh in India. Water Hyacinth was taken from Arpa river in Bilaspur washed thoroughly in running tap water to avoid any surface contamination, blotted with clean blotting paper for any surface moisture avoiding damage to root and leaf. During investigation we have taken three big jars for experimental work.

- Sample no 1-100% Tap water
- Sample no 2-100% hand pump water near industry
- Sample no 3-Tap water and water hyacinth plants

3.1. The Laboratory Test Parameters

The laboratory test parameters were chosen Temperature pH, Electrical conductivity (EC), Total Solids Total Dissolved solids (TDS), Salinity, Alkalinity, Turbidity, Biochemical Oxygen Demand (BOD) and Dissolved Oxygen (DO).

3.2. Methodology of the Treatment of Water Sample

Different parameters of water samples were measured separately Temperature pH, Electrical conductivity (EC) and Total dissolved solids (TDS) of the sample by digital potable instrument and Turbidity was measured by Nephelometric turbidity meter on the laboratory. Analysis of Salinity, Alkalinity, Dissolve Oxygen (DO), Biological Oxygen Demand (BOD), were done according to standard methods by Trivedi and Goel [11], APHA (1985) and APHA (1999) [11-13].

3.3. Sample Preparation for Removal of Heavy Metals

Fresh samples were chopped to 3.0 cm in length and mixed uniformly. Mixed samples were subjected to hot air oven for estimation of dry matter. The remaining samples were sun dried for about 7 days at an environmental temperature of 22.8-33.8°C and relatively high humidity. Approximately 500g of dried, uniformly ground samples were collected for proximate ana.



Figure 2.
Fresh, Dry and Chopped Sample of Water Hyacinth.

4. Result and Discussion

4.1. Study of Growth Rate and Physico-Chemical Analysis by Water Hyacinth

Water Hyacinth is aquatic vascular plant with rounded, upright and shiny green leaves and lavender flowers. It is fast growing perennial with great reproduction potential. Growth of Water Hyacinth is primary dependent on ability of plant to use solar energy, nutrient composition of water, cultural methods and environmental factors. The effect of Water Hyacinth has resulted in significant decrease in turbidity and due to which the removal of flocs and reduction in organic matters in water have been observed. The primary purpose of this study is to make use of the water hyacinth plant for the purification of the tap water and hand pump water. The common water Hyacinth (*Eichhorniacrassipes*) is vigorous growers known to double its population in only 12 to 15 days. Optimal water pH for growth of this aquatic plant is neutral but it can tolerate pH values from 5 to 10. This is very important fact because it points that water hyacinth can be used for treatment of three types of contaminated water.



Figure 3.
Water hyacinth growth is on 1st day.



Figure 4.
Water hyacinth growth is double after 12 days.

In the present work, optimal water temperature for growth recorded 28-30°C. But temperatures above 33°C it's inhibited further growth. Water Hyacinth is growing fastest at temperatures from 20°C to 30°C, but growth fully stops at temperatures from 8°C-15°C and above 35°C. To understand the growing ability of Water Hyacinth, its growth rate was studied. Above **Figure 3** and **Figure 4** shows a Water Hyacinth plant which was taken and allowed to grow in a bucket of capacity 16 lit. With tap water in Sirgitti A rea.

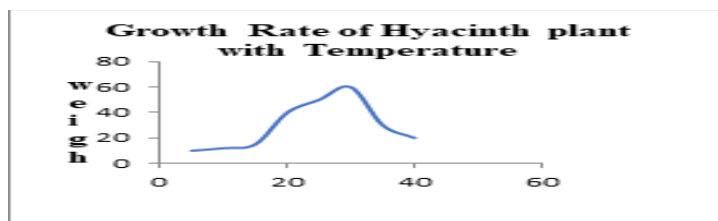


Figure 5.
The Growing ability of Water Hyacinth Plant.

Weight of this Water Hyacinth plant was taken weekly in a digital weighing machine (Least count of 1.9g) for seven consecutive weeks and a weight Vs time graph was obtained. The result showed the growth rate of water hyacinth was 60gm./week. Per week Growth rate of water hyacinth especially in the seventh week the growth of Water Hyacinth was more due to the growth of new leaves and development in its root system. From the graph obtained in figure 5 it can be concluded that Water Hyacinth can double its population in less than two weeks, with an average local temperature of 24°C to 34°C. This study focused on temperature, EC Dissolved Oxygen, BOD, turbidity because these water quality parameters have been shown to be important drivers in the growth and distribution of various fish species. Water Hyacinth was cultured in the tank of approximately 6ft X 4ft X 3.0 ft. dimension. The parameters studied were pH, EC, DO, BOD, TDS, Salinity, Alkalinity and Turbidity in the separate jars. Six months of experimental investigation showed that Water Hyacinth reduced considerably all the physico-chemical parameters and increased the Dissolved Oxygen (DO) to a significant level therefore it is concluded that Water Hyacinth is highly efficient in purification of polluted tap water as well as hand pump water in respect of physicochemical parameters. In the present study showed that it was made to find the potential of Water Hyacinth in the treatment of polluted tap water in industrial Areas.



Figure 6.
Measurement of pH with pH digital potable meter.

An experimental studied, Evapotranspiration of Water Hyacinth in Two jars of 10 litres capacity each one with Water Hyacinth and another without Water Hyacinth were taken and filled with equal volume of water 10 litres. After 48 hours (2 days) the depleted water levels were measured in both the jars. The difference between the readings of the jar will give the transpiration rate of water hyacinth whereas the reading of the jar in which the water hyacinth was kept will give the Evapotranspiration. It was also observed that there was just a little difference between the pH of the water that is underneath the mats of *E.crassipes* and that of the water that is free from *E.crassipes* mats. The concentration of the Dissolved Oxygen (DO) in the water is above the minimum limit of 5.0mg/l in fresh water that is necessary for the survival of aquatic fauna. The values of BOD, however, showed great variation among the samples. Whereas sample 2 (100% hand pump water near industrial area) had the highest BOD concentrations of 22.4mg/l, sample 1 (100% tap water) had the lowest 12.0mg/l, since the percentage total organic matter (%TOM) in the plants are high (about 90.8mg/100g) and thus, requires higher amounts of dissolved oxygen to decompose. The salinity of water 7.25mg/l was low enough to favour the proliferation of *E.crassipes*. The salinity as well as the alkalinity showed very minimum variation among the samples 2 and 3 as compared to sample 1. The experimental study showed that TDS, EC and pH value after purification decreased significantly in all the three water samples. For sample no 3, we got to see very good results obtained and it was showed maximum reduction of pH TDS, and EC by water hyacinth. The pH and EC reduction by water hyacinth plant was maximum in sample no 2 (In hand pump water). pH from 8.78 to 7.43 in sample no 2 and from 7.92 to 7.44 in sample no 1. While EC decreases from 1218 moh cm⁻¹ to 943 moh cm⁻¹ in sample no 2 and 1046 moh cm⁻¹ to 441 moh cm⁻¹ in sample no 3. This reduction in pH is due to absorption of pollutants by root of water hyacinth plant and EC due to consumption of ions by Water Hyacinth plant.

During the study DO value increased in all the samples in the experimental year August 2019 to January 2020. The maximum value DO was found to be 8.6mg/l at S-2 and 9.2 in sample no 3 due to Photosynthesis helps in maintaining the oxygen supply for plants while respiration helps in maintaining dissolved oxygen content in the water. The DO increase in sample no 1 was minimum where it increases from 4.68 mgL⁻¹ to 6.40 mgL⁻¹. The photosynthetic activities in plants increase the DO in water, thus creating aerobic conditions in the system. Similar findings had also been reported by other author [13, 14]. BOD is the amount of oxygen that will be consumed by microorganism during the biological reaction of oxygen with organic material and. The BOD reduction by test plant (*Eichhornia crassipes*) was maximum in sample no 3 where it decreases from 39.8 mgL⁻¹ to 18.3 mgL⁻¹ and from 44.6 mgL⁻¹ to 22.8 mgL⁻¹ in sample no 2. The turbidity reduction by Water Hyacinth plant (*Eichhornia crassipes*) was maximum in sample no 2 and minimum in sample no 1 where it decreases from 5.26 NTU to 2.36 NTU. This reduction in turbidity is due to the root hairs as they

have electrical charges of colloidal particles such as suspended solids and cause them to adhere on the roots where they are slowly digested and assimilated by the plant and microorganism [15-17].



Figure 7.
Measurement of electrically conductivity by digital conductometer.

5. Conclusion

The root system provides an enormous surface area that absorbs and accumulates the water and nutrients essential for growth, as well as other non-essential contaminants. The present study clearly indicated that the underground water samples studied were generally safe for drinking purposes. However, there were specific instances of chemical pollution in some samples. Water from these hand pumps are frequently used by population in vicinity of these hand pumps for their domestic purposes. Some of the physico-chemical parameters have either crossed the threshold limit or are near it for certain samples. WHO has recommended 6.0 mg/l as the maximum permissible value for biological oxygen demand, but the BOD values found never exceeded this limit at all the sampling stations indicating no biological pollution load on these water bodies. During the study period, the value of Dissolved Oxygen observed were many times higher than the maximum permissible limit of 5 mg/l prescribed by WHO at all the sampling stations. Oxygen transfer by aquatic plants in to the root areas plays an important role in the growth of aerobic bacteria and subsequent degradation of waste water. Moreover, the higher suspended solids in the effluent samples help in enhanced microbial activity as additional substrate on the roots of aquatic plants.

Organic pollutants enter the water system due to domestic and animal sewage, industrial waste from food processing plants and paper mills, run off from agriculture lands etc. Decrease in dissolved oxygen is an indication of water pollution due to organic pollutants. In view of these findings, it is suggested that regular monitoring of the physico-chemical parameters is required at strategically selected sampling sites, otherwise these areas will become more and more prone to water related hazards and the ultimate sufferers will be the people residing in the nearby areas. Therefore, it is concluded that *Eichhornia crassipes* is highly efficient in purification of polluted water in respect of physicochemical parameters.

References

- [1] W. Cunningham and W. Saigo, "Environment science," 3rd ed. United Kingdom: WC Brown Publishers, 1995, pp. 286-287.
- [2] S. Trivedi and P. Goel, *Chemical and biological methods for water pollution studies*. India: Env Pub Karad, 1984a.
- [3] A. Khan, "Tackling water pollution govt of India publication," n.d.
- [4] K. Venkataeswarlu, "Water chemistry", 1st ed. India: New Age International Publishers, 1999, pp. 2-4.
- [5] S. Purohit, "Microbiology fundamentals and applications." India Agrobios Publishers, 2002, pp. 439-443.
- [6] D. Krantz and B. Kifferstein, "Water pollution and society," pp. 1-11, n.d.
- [7] S. Reed and R. Crites, "Natural systems for waste management and treatment," ed: McGraw Hill second edition Todd, J, 1995.
- [8] C. Boyed, "Vascular aquatic plants for mineral nutrient removal from polluted waters," *Economic Botany*, vol. 24, pp. 95-103, 1970. <https://doi.org/10.1007/bf02860642>
- [9] G. Gupta, "Use of water hyacinth in wastewater treatment," *Journal of Environmental Health*, vol. 43, pp. 80-82, 1982.
- [10] A. Villamagna, *Ecological effects of water hyacinth Eichhornia crassipes on lake Chapala, Mexico*. Blacksburg, Virginia, USA: Virginia Polytechnic Institute and State University, 2009.
- [11] S. Trivedi and P. Goel, *Chemical and biological methods for water pollution studies*. India: Envi Pub Karad, 1984b.
- [12] American Public Health Association, *Standard methods of water and wastewater analysis*. United States: American Public Health Association, 1985.
- [13] G. Baskar, V. Deeptha, and A. A. Rahman, "Treatment of wastewater from kitchen in an institution hostel mess using constructed wetland," *International Journal of Recent Trends in Engineering*, vol. 1, no. 6, p. 54, 2009.
- [14] S. Yadav, A. Jadhav, S. Chonde, and P. Raut, "Performance evaluation of surface flow constructed wetland system by using *Eichhornia crassipes* for wastewater treatment in an institutional complex," *Universal Journal of Environmental Research and Technology*, vol. 1, pp. 435-441, 2011.
- [15] S. Dipu, A. Anju, V. Kumar, and G. Salom, "Phytoremediation of dairy effluent by constructed wetland technology using wetland macrophytes," *Global Journal of Environmental Research*, vol. 4, pp. 90-100, 2010. <https://doi.org/10.1007/s10669-011-9331-z>
- [16] S. Neralla, R. Weaver, T. Varvel, and B. Lesikar, "Phytoremediation and on-site treatment of septic effluents in sub-surface flow constructed wetlands," *Envi Techn*, vol. 20, pp. 1139-1146, 2007. <https://doi.org/10.1080/0959332008616911>
- [17] R. A. Shah, D. Kumawat, N. Singh, and K. A. Wani, "Water hyacinth (*Eichhornia crassipes*) as a remediation tool for dye effluent pollution," *International Journal of Natural Sciences*, vol. 1, no. 2, pp. 172-178, 2010.