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Rhizofiltration is Cost Effective and Eco-Friendly Method for the Remediation of Heavy Metals from Ground Water

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Abstract

Water is the most precious gift of nature and one of the vital elements involved in the existence and continuation of life. Groundwater is the primary source of water for human consumption as well as foragricultural and industrial uses in many regions all over the world.Ground water polluted by heavy metals becomes an environmental problem, though the metals are constituent of nature. Heavy metals have long been recognized as one of the most important pollutants in the waters because of their toxicity, mutagenic and carcinogenic effects in animals. They constitute the most widely distributed group of highly toxic and retained substances.Lime-soda process and ion exchange process are generally used for removal of hardness causing substances including heavy metals. Plant based technologies such as rhizofiltration are the cost effective and environmentally friendly for removal of heavy metals. Rhizofiltration is a technique of utilising plant root to absorb heavy metals from the ground water. In the present work ground water samples were collected from different villages of Purna river basin. Samples were analysed heavy metals like Cu, Fe, Cd, Pb, Mn, Zn Cr, and Ni. Heavy metals are assessed before and after Lime-soda, Ion exchangeand rhizofiltration treatment. The result of the study reveals that Rhizofiltration is potential technique for removal ofheavy metals from ground water.

Key wards:*Ground water, Rhizofiltration, Heavy metals, Water pollution, Metal toxicity*.

I INTRODUCTION

Today water pollution is the biggest problem for human beings' characterization by deterioration of the water quality as a result of various human activities which makes water unfit for drinking and domestic purposes. Many toxic heavy metals have been discharged into the environment as industrial waste, causing serious soil and water pollution [1].

Ground water has been traditionally considered to be pure form of water because of its filtration through soil and its long residence time on the ground. However, ground water is not as pure as traditionally assumed as water is an excellent solvent and it can contain lots of dissolve chemicals[2]. Heavy metal contamination of ground, stream and river water ecosystem is a worldwide environmental problem and between the wide diversity of contaminants affecting water resources, heavy metals receive particular concern considering their strong toxicity even at low concentrations [3]Water pollution due to heavy metal has been a major cause of concern since long due to heavy metal contamination in aquatic environment have increased the awareness about their toxicity. Heavy metals have long been recognized as one of the most important pollutant in the ground water because of their toxicity, mutagenic and carcinogenic effect in animal. Heavy metal contamination of ground, stream and river water ecosystem is a worldwide environmental problem and wide diversity of contaminant affecting water resources.The toxicity of metals most commonly involves the brain and the kidney, but other manifestation occurs and some metals, such as arsenic are clearly capable of causing cancer. An individual with metal toxicity, even if high dose and acute typically has very general symptoms such as weakness or headache. Chronic explore to metals at high enough level to cause chronic toxicity effect can also occur in individual who have no symptoms [4]. Health risk due to heavy metals include reduced growth and development, cancer, organ damage, nervous system damage and in extreme cases death. Explore to some metals. Such as mercury and lead may also leads to autoimmunity. Heavy metals become toxic when they are not metabolized by body and accumulate in the soft tissue [5].Bioremediation is emerging as an effective innovative technique for treatment of a wide variety of contaminant. This technology includes phytoremediation and rhizoremediation. Bioremediation is cost effective solar driven, faster than natural attenuation and high public acceptance. Bioremediation has emerged as an integrated tool box for environment clean up [6]Rhizofiltration is a technique of utilizing plant root to absorb, concentrate and precipitate toxic metals from contaminated ground water or polluted effluent. It is one kind of phytoremediation. Most researcher believe that plants used for phytoremediation should accumulated the metals in phytoremediation technique the root system of plants interact with the contaminant or polluted site for making the area pollution free. It is a potential technique for removal of wide ranges of organic and inorganic contaminant. [7]. The contaminants are either absorbed in the root surface or are absorbed by the plant for rhizofiltration. A variety of plants species have been found to be effective in removing toxic metal ions such as Cu^{2+}, Cd^{2+}, Cr^{6+}, Ni^{2+}, Pb^{2+} and Zn^{2+} from aqueous solution [8].

II MATERIAL AND METHOD

Sampling:

In the present work the ground water samples were collected from saline track of Buldana District, Maharashtra, India, in winter season 2017 for the determination heavy metals by standard methods [9]. For this purpose, all different locations/sampling sites were outlined and samples were collected. Before sampling, the bottles were washed thoroughly with the detergent, tap water and then with distilled water.Nine villages where kidney failure patients are reported and the main source of drinking water is groundwater were selected as target area. Those villages are Jalgaon, Borada, Khandavi, Yerali, Zodaga, Panhera, Changefal, Niwana and Nirod of Buldana District.

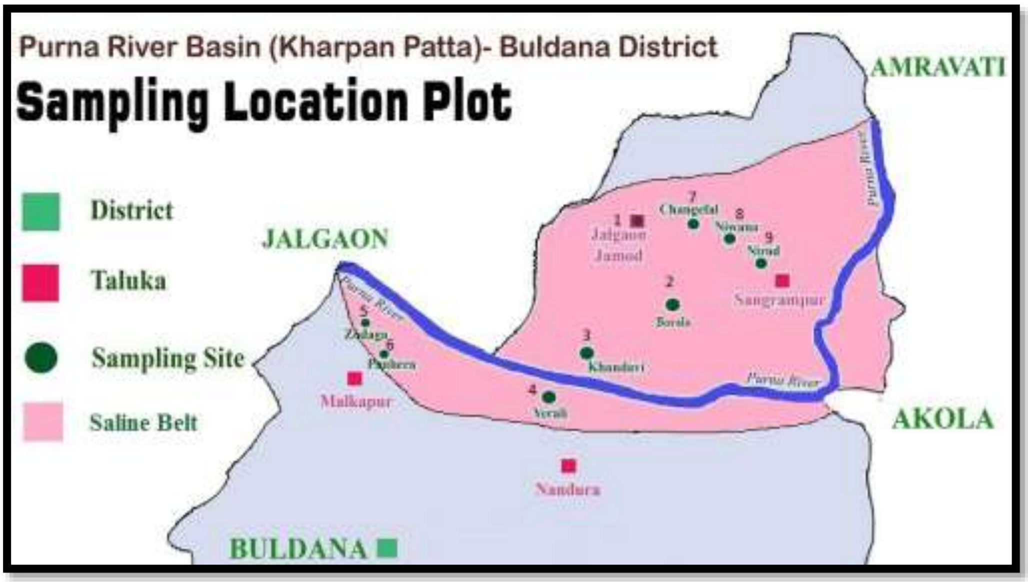

Fig-1 Sampling Location Plot.

Rhizofiltration is defined as the use of plants, both terrestrial and aquatic; to absorb, concentrate and precipitate contaminants from polluted aqueous sources with low contaminant concentration in their roots10].In this work, Brassica Juncea (Indian mustard) is chosen as a test plant for rhizofiltration as the condition to grow mustard plant in target area are suitable. Further it is reported to accumulates high level of heavy metals in both shoot and root [11.12.13]. The seeds of Brassica Juncia were sown in soil. Regular watering was done to the growing seedlings at the same time supplement was also provided to the plants for their growth and development. Once the plants of B. Juncia grown well the plants were poked and wash with distilled water. After washing the roots of plants was dipped in nine plastic bottle containing samples collected from nine different sampling locations. Each bottle contains 750 ml of contaminated water. The plastic bottle was cut in such a way that roots were fitted in to the bottle and assuring minimum evaporation losses. As the roots were dipped in to contaminated water it absorbs the heavy metals from contaminated water along with the water. After 48 hours the plants were removed from contaminated water and samples were collected. The collected samples were analysed for its heavy metals.

The ground water sample were analysed for its heavy metal ion concentration. Metal ions were determined by Atomic Absorption Spectrophotometry at Central Instrumentation Cell S.G.B. Amravati University Amravati before and after rhizofiltration treatment.

Fig-2 Indian Mustard (Brassica Juncia)

Fig-3 Remediation of Heavy Metals by Using Indian Mustard (Brassica Juncia)

III RESULT AND DISCUSSION

The results of the present study are tabulated in table number1. Thecontent of heavy metal such as Cu, Fe, Cd, Pb, Mn, Zn, Cr andNi in the groundwater sampleswere assessed before and after rhizofiltration. From the result it reveals that theheavy metal in ground water reduces to certain level afterrhizofiltration treatment.

Table 1: AAS analysis of water sample for heavy metal ions before after rhizofiltration (RF)treatment.

Sr.No.	Element	Process	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	WHO Guideline
1	Cu	BT	0.138	0.134	0.144	0.149	0.140	0.136	0.137	0.146	0.141	2mg/dm3
		ARF	0.099	0.094	0.100	0.093	0.098	0.095	0.091	0.098	0.093	
2	Fe	BT	0.164	0.162	0.168	0.166	0.162	0.164	0.167	0.165	0.163	50mg/dm3
		ARF	0.119	0.115	0.118	0.121	0.199	0.122	0.125	0.117	0.119	
3	Cd	BT	0.041	0.040	0.044	0.042	0.046	0.044	0.047	0.045	0.043	0.003 mg/dm3
		ARF	0.016	0.015	0.016	0.018	0.015	0.016	0.018	0.015	0.017	
4	Pb	BT	0.051	0.049	0.053	0.054	0.051	0.057	0.052	0.050	0.055	0.01 mg/dm3
		ARF	0.018	0.013	0.015	0.014	0.013	0.018	0.015	0.019	0.016	
5	Mn	BT	0.046	0.043	0.042	0.044	0.042	0.045	0.042	0.041	0.045	0.4 mg/dm3
		ARF	0.019	0.019	0.017	0.018	0.018	0.017	0.018	0.016	0.017	
6	Zn	BT	0.056	0.050	0.048	0.052	0.049	0.053	0.051	0.054	0.055	0.01-0.05 mg/dm3
		ARF	0.011	0.011	0.016	0.017	0.019	0.013	0.017	0.013	0.012	
7	Cr	BT	0.039	0.041	0.037	0.039	0.040	0.041	0.039	0.043	0.039	0.05 mg/dm3
		ARF	0.011	0.012	0.014	0.017	0.014	0.015	0.013	0.15	0.14	
8	Ni	BT	0.047	0.052	0.049	0.050	0.048	0.049	0.053	0.050	0.054	0.07 mg/dm3
		ARF	0.019	0.021	0.018	0.015	0.016	0.19	0.020	0.022	0.019	

Copper (Cu):

Copper is both an essential nutrient and a drinking-water contaminant.In the present study concentrations of copper are well below the WHO Guidelines for drinking water quality. Even though copper is an essential element inhuman diet but human eats and drinks copper approximately 1.00µg per day. It is also occurrednaturally in plants and animals. If the concentration of copper exceeds beyond the permissible limit, then the immediate health effects are vomiting, diarrhea, stomach cramps and nausea. The effects are much higher in children under one year old than adults. However, long term exposure which is more than 14 days to copper in the drinking water can cause serious problems like kidney and liver damages in infants [14].Measured values are shown in Table 1. for all Nine samples the concentration of copper decreases after rhizofiltration. The concentrations of copper ion in ground water for various locations were given in chart 1.

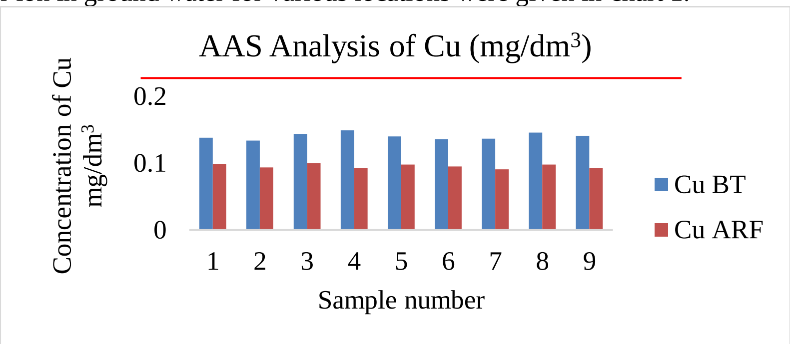

Chart -1. Graph showing the Copper in mg/dm^3 at the different sampling locations during Winter season-2017.

Iron (Fe):

Iron is the fourth most common element in the earth‘s crust.Iron is an essential element in human nutrition, particularly in the iron (II) oxidation state. Estimates of the minimum daily requirement for iron depend on age, sex, physiological status and iron bioavailability and range from about 10 to 50 mg/day [16]. In the present study concentrations of Iron are well below the WHO Guidelines for drinking water quality. Measured values shows in Table 1, the comparison levels of iron before and after rhizofiltration treatment is shown in chart 2.

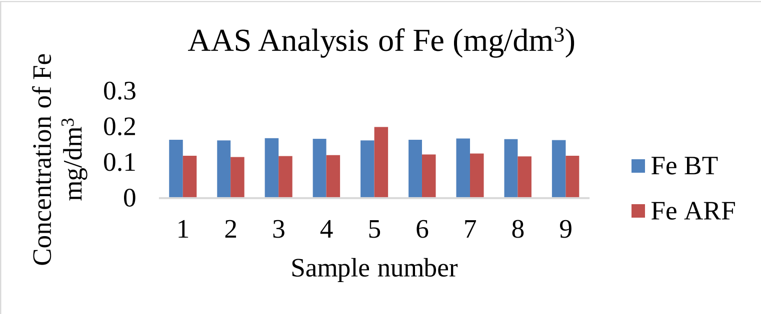

Chart -2. Graph showing the Iron in mg/dm3 at the different sampling locations during Winter season-2017.

Cadmium (Cd):

Cadmium is released to the environment in wastewater, and pollution caused by contamination from fertilizers [17]. Generally, cadmium is found naturally in small quantities in water. Cadmium can bereleased to drinking water from the corrosion of some galvanized plumbing and water mainwater piping materials.The permissible limit for cadmium in Drinking water no exceed than 0.003Mg/L as per WHO. Cadmium primarily accumulates in kidney, may be due to the long-term exposure of cadmium to lower level the people of the area are affecting by possible kidney related diseases. In the present work it is observed that the concentration of Cadmium is beyond the limits laid down by WHO guideline for all samples. The measured values are shown in Table 1,For all samples the concentration of cadmium shows significant decrease in Cd Concentration after rhizofiltrationas shown in chart 3.

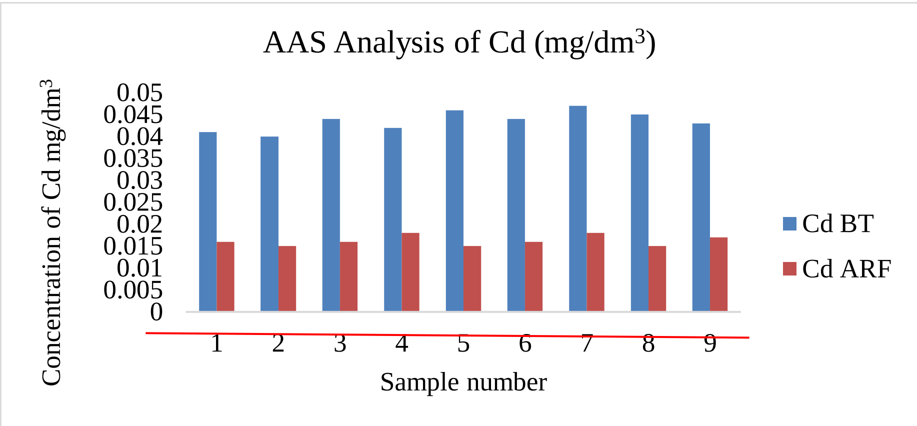

Chart -3. Graph showing the Cadmium in mg/dm3 at the different sampling locations during Winter season-2017.

Lead (Pb):

Lead is common heavy metal found in industrial effluent, particularly in developing countries. The main source of Lead is mining and smelting activities. Lead is toxic to many organs of human body including heart, kidneys, reproductive and nervous system [18]. The permissible limit of Lead in Drinking water is 0.01Mg/L as per WHO guideline. In the present work it is observed that the concentration of lead is beyond the WHO guideline for all samples. The measured values show in Table 1, from the graph it reveals that there is a decrease in concentration of Pb after RF treatment concentration of Lead is decreases near to the permissible limits, whichis shown in chart 4.Exposure to lead is very dangerous for young children compared toan adult. Numerous health hazards seen on population of the area showing symptoms of acute poisoning are tiredness, severe intestinal cramps, paralysis of nerves, loss of appetite and fatigue, slight abdominal discomfort, irritability, anemia and in case of children behavioral changes may occur due to lead consumption through drinking water [19]

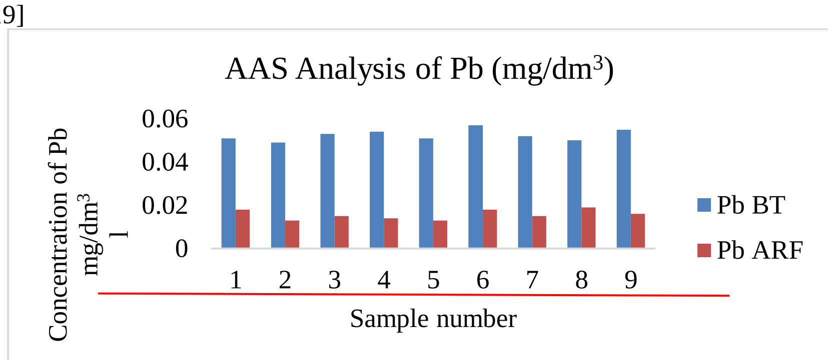

Chart -4. Graph showing the Lead in mg/dm^3 at the different sampling locations during Winter season-2017.

Manganese (Mn):

Manganese occurs in the natural waters in both the dissolved and a suspended form with the anaerobic ground water often contains higher levels of dissolved Manganese. Manganese is an essential element for human beings. Manganese is present in all tissues of the body, the highest levels usually being found in the liver, kidney, pancreas and adrenals[20]. As per WHO guideline the permissible of Lead in drinking water is 0.4mg/l. [17] In the present study concentrations of Manganese are below the WHO Guidelines for drinking water quality. Measured values shows in Table 1, the comparison levels of Manganese before and after RF treatment is shown inchart 5.

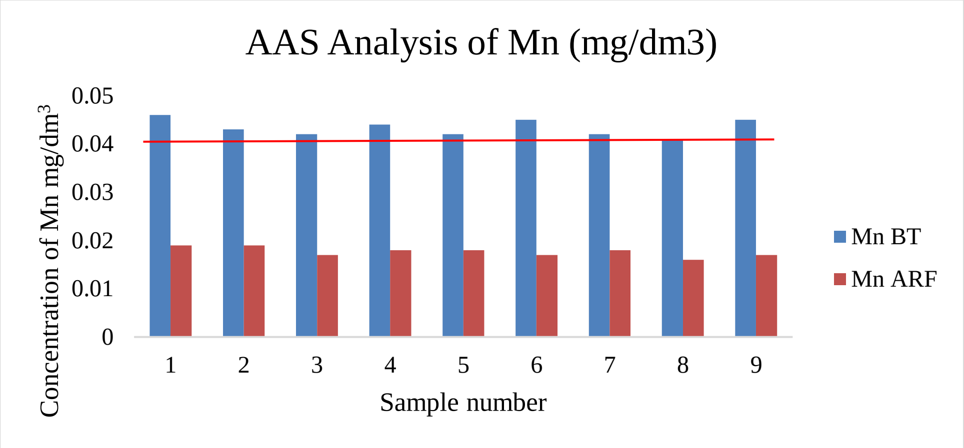

Chart -5. Graph showing the Manganese in mg/dm^3 at the different sampling locations during Winter season-2017.

Zinc (Zn):

Zinc is an essential and beneficial element in the human metabolism. It is necessary for the functioning of the various enzyme systems including alkaline phosphatase, carbonic anhydrase, alcohol dehydrogenase etc. [21]. Although levels of zinc in surface water and groundwater normally do not exceed 0.01 to 0.05 mg/l, respectively [16]. Too little zinc can cause slow wound healing and skin sores, decreased sense of taste and smell, loss of appetite and damage in immune system.In the present study concentrations of Zinc were beyond the WHO Guidelines for drinking water quality for some samples. Measured values shows in table 1.The comparison levels of Zinc before and rhizofiltration treatment is shown in chart6. From the figure it shows that the concentration of Zn decreases significantly after rhizofiltration.

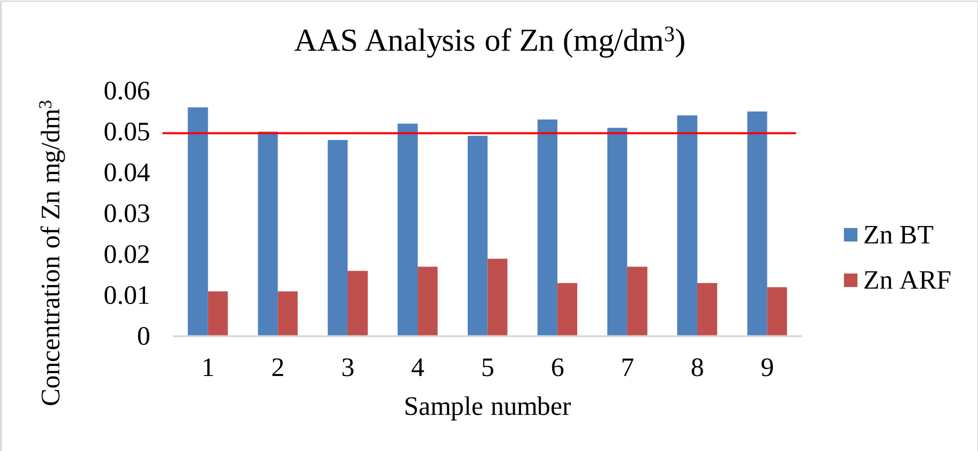

Chart -6. Graph showing the Zinc in mg/dm^3 at the different sampling locations during Winter season-2017.

Chromium (Cr):

Chromium is an important industrial metal used in diverse products and processes [22]. Chromium is found naturally in rocks, plants, soil and volcanic dust, humans and animals and anthropogenic sources of chromium-6 in drinking water are discharges from steel and pulp mills, and erosion of natural deposits of chromium-3. The maximum allowable limit for chromium as per WHO guidelines is 0.05 mg/L. Chromium causes various health effects such as allergy, skin rash, irritation, nosebleeds, stomach ulcers, respiratory problem, weakened immune system, kidney and liver damage, alteration of genetic material, lung cancer and in extreme case cause death [23]. Chromium concentration levels in all studied samples were below then WHO Standards. The concentration levels of chromium in all the samples are shown in Table 1 and the comparison levels of Chromium before and after rhizofiltration treatment is shown inchart7.

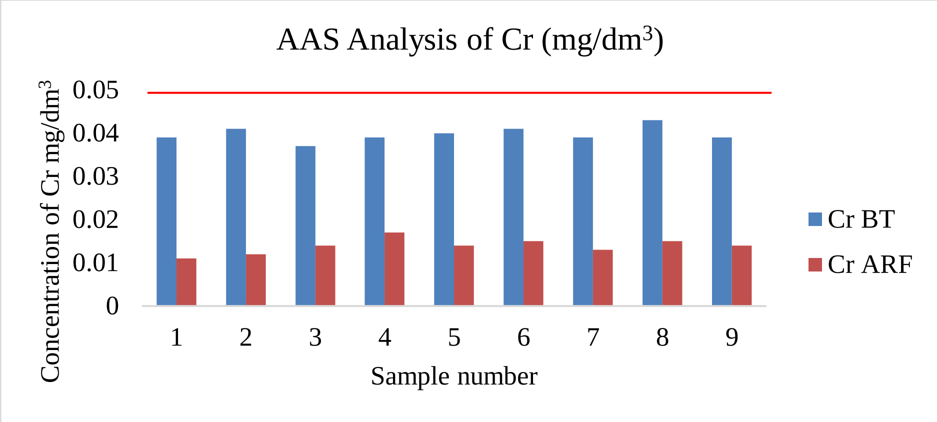

Chart -7. Graph showing the Chromium in mg/dm^3 at the different sampling locations during Winter season-2017.

Nickel (Ni):

Nickel is primarily found combined with oxygen or sulphur as oxides or sulphides that occur naturally in the earth‘s crust and used in a wide variety of metallurgical processes such as electroplating and alloy production as well as in nickel-cadmium batteries [24].maximum allowable limit for Nickel as per WHO guidelines is 0.07mg/L. Health hazards due to nickel uptake are sickness, dizziness, birth defect, asthma, chronic bronchitis, allergic reaction, respiratory problem, heart disorder and cancer of nose, larynx and lung. Allergic contact dermatitis is the most prevalent effect of nickel in the general population[16].Concentration levels of Nickel in all studied samples were below then WHO Standards. The concentration levels of Nickel in all the samples are shown in Table 1 and the comparison levels of Nickel before and after rhizofiltration treatment is shown in chart 8.

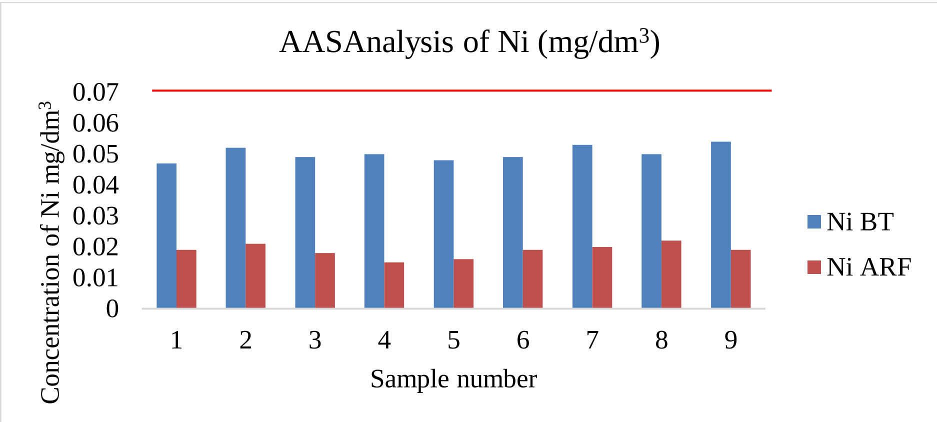

Chart -8. Graph showing the Zinc in mg/dm^3 at the different sampling locations during Winter season-2017.

IV. CONCLUSION

The results obtained for the heavy metals concentration shows that Heavy metals like Cd, Pb exceed the limits laid down by WHO for all samples, where as Mn, Zn exceed the permissible limits for some of the sampling location. From the result it is clear that significant decrease in concentration of metal ions after rhizofiltrationtreatment for all samples. From the result it is clear that the quality of water is poor and not good for drinking and domestic use.It is, therefore, strongly recommended thatthe ground water needs treatment to reduce the heavy metal ion concentration. From the result it reveals that Rhizofiltrtion is very useful, cost effective and eco-friendly technique to reduce metal ion concentration in ground water.

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