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Physicochemical Parameter and Some Heavy Metals Analysis in Ground Water and Its Remediation

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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 for agricultural 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 for physico-chemical parameters and some heavy metals like Cu, Fe, Cd, Pb, Mn, Zn Cr, and Ni. Heavy metals are assessed before and after Lime-soda, Ion exchange and rhizofiltration treatment. The result of the study reveals that Rhizofiltration is potential technique for removal of heavy metals from ground water.

***Keyword:* Ground water physico-chemical parameter, Rhizofiltration, Heavy metals**

1. INTRODUCTION

Water plays a vital role in the development of communities; hence a reliable source of water is essential for the existence of both human and animals [1].Ground water is one of the major sources of drinking water in the study area hence it is important to assess the groundwater quality with respect to physico chemical parameter and heavy metal contamination[2] 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 [3]. Heavy metal contamination of ground, stream and river water ecosystem is a worldwide environmental problem [4] and between the wide diversity of contaminants affecting water resources, heavy metals receive particular concern considering their strong toxicity even at low concentrations [5]. Some heavy metals like Fe, Zn, Cu, Mg have been reported to be of bio importance to man. In very small quantities, even Cr and Ni are required in the body. However, some other metals like As, Cd, Pb has been reported to have no known importance in human biochemistry and physiology, and consumption even at very low concentrations can be toxic. Even for those that have bio importance, dietary intakes have to be within regulatory limits as excesses may result in poisoning or toxicity. Heavy metals are also known to be toxic to both humans and other living forms, with their accumulation over time causing damage to the kidney, liver, and reproductive system in addition to cancer [6]. During last few years, it is reported that the patients affected by water pollutants are facing serious health problems like kidney failure, hair loss and cardiovascular damage. If the population use untested and untreated water for drinking this could be probably the cause of so many water borne diseases [3].

Heavy metals are considerable environment concern due to their toxicity and accumulative behaviour; hence it is not advisable to consume polluted water without subjecting it to proper and effective treatment. Generally, issues in the environmental pollution of heavy metals in ground water resources is very scanty [7], hence the objective of this study is to assess heavy metal concentration in ground water resources across Purna river basin. In the present work the ion exchange process (IEP, lime soda process (LSP) and Rhizofiltration (RF) techniques were used for the remediation of presence of metal ions in contaminated water.

2. MATERIAL AND METHOD

2.1 SAMPLING

In the present work the ground water samples were collected from saline track of Buldana District, Maharashtra, India for the determination of physico-chemical parameters and heavy metals by standard methods. Samplings of ground water were done by standard methods [8]. Sampling was done in Winter season in the month of January. Special precautions were taken during the collection of samples. Before collecting the samples, at each sampling location water samples were collected in two pre-cleaned containers for duplicate measurement. The bottles were rinsed three times with the ground water sample of the location and collected the final sample to avoid the contamination. 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. The parameters were determined at research laboratory and metal ion at Central Instrumentation Cell S.G.B. Amravati University Amravati before and after LSP, IEP, and RF processes. The details of sampling locations have been summarized in **Table -1.**

In the present work the presence of metal ions in contaminated water can be removed by ion exchange, Lime-soda and rhizofiltration process. Ion exchange resins are insoluble, cross-linked, long chain organic polymer with a micro porous structure and the functional group attached to the chain responsible for the ion-exchange properties. Resin containing acidic functional group (-COOH, -SO3H etc.) are capable of exchanging H+ ions with other cation present in moving water phase. The contaminated water is passed through cation exchange column, where cations like Ca2+, Mg2+ and heavy metal ions are removed from water.[9] In Lime Soda Process, the soluble metal salts in contaminated water are chemically converted into insoluble
compounds by adding calculated amount of lime [Ca(OH)2] & soda [Na2CO3] [10]

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 roots.[11-12]. 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 is suitable. Further it accumulates high level of heavy metals in both shoot and root [1]. B. Juncea seedlings can be naturally grown in farm. After 30 to40 days mustard plants were collected from farm then wash with distilled water and dipped in water sample for 2 days (48 hr.) after 48 hours sample were collected and analysed for physico-chemical parameter & Metal ion before and after LSP, IEP and Rhizofiltration treatment.

Table:1 Details Of Sampling Locations

SR.NO	SAMPLE NO.	SAMPLE LOCATION
1	S-1	JALGAON
2	S-2	BORADA
3	S-3	KHANDAVI
4	S-4	YERALI
5	S-5	ZODAGA
6	S-6	PANHERA
7	S-7	CHANGEFAL
8	S-8	NIWANA
9	S-9	NIROD

3. ANALYTICAL METHODOLOGY

The ground water sample were analysed for various parameter like TDS, Hardness, pH, conductivity Alkalinity, Turbidity, and dissolve metal ion [11]. The chemicals used were of AR grade. Utmost care was taken during sampling to avoid any kind of contamination.

Table 2 Methods employed for determination Of Physico-chemical parameters.

Sr. No	Parameters	Methods Employed
1	pH	pH metry
2	Temperature	Thermometer
3	Total Dissolve Solid	TDS meter
4	Hardness	EDTA Titration
5	Conductivity	Conductometry
6	Alkalinity	Titration
7	Turbidity	Turbidimeter
8	Metal Ions	Atomic Absorption Spectrophotometry(AAS)

4. RESULT AND DISCUSSION

Groundwater has been considered a safe source of potable water since the ages and till date a lot of people depend on it for drinking. But the quality of ground water is deteriorating, and it is of paramount importance to assess the quality regarding various parameters. The physico-chemical, heavy metal & biological parameters of groundwater need to be studied to determine its quality. The present study mainly focuses on the physico-chemical characteristics and heavy metal concentration in the ground water from the study area and the results obtained are compared with potable water quality standards laid down by World Health Organization (WHO).

The results of the present study are tabulated in table number 3 and 4. Physico-chemical parameters like TDS, Total hardness, electrical conductivity, metal ion content and pH are important in assessing the water quality and finding its suitability for drinking purpose [13] The result shows that TDS and hardness value of maximum samples were exceed the WHO prescribed limit of drinking water 500 mg/dm3. Due to excessive hardness in drinking ground water people at some sampling sites may affect adversely by heart and kidney disorder. From the result the value of total hardness of water are beyond the limits laid down by WHO i.e., 500 ppm. pH of all samples is considerably increased after LSP and IEP treatment as compared to rhizofiltration. The results are tabulated in Table number 3 and are compared with water quality standards given by WHO and other agencies. Content of heavy metal such as Cu, Fe, Cd, Pb, Mn, Zn, Cr and Ni in the groundwater samples were assessed before and after LSP, IEP and RF treatment. From the result it reveals that the physico-chemical parameter and concentration of heavy metal in ground water reduces to certain level after treatment.

It was observed that the temperature variations at all sites are nearly uniform for all samples. pH of all samples were raised to 11 for LSP, increased up to 9 for IEP and 8.0 after RF. It may be attributed to the addition of Na^+ and OH^- ions in IEP and lime in LSP The hardness of some water samples were beyond the permissible limit but it was decreases to certain level after IEP, LSP and RF treatment. Conductivity and alkalinity of some water samples were increases after treatment, but the turbidity of all samples decreases. The results are tabulated in Table 3 and are compared with water quality standards given by WHO and other agencies. The concentration of heavy metal such as Cu, Fe, Cd, Pb, Mn, Zn, Cr & Ni mg/l in the groundwater sample S1 to S9 were assessed before and after LSP, IEP and RF. From the result it is reveals that the concentration of heavy metal in ground water reduces to certain level after the treatment of lime soda, ion exchange and rhizofiltration treatment, but at the same time some physico-chemical parameters like pH, Conductivity Alkalinity shows variation with increase in value.

Copper (Cu):

Copper is both an essential nutrient and a drinking-water contaminant [14]. In the present study concentrations of copper are well below the WHO Guidelines for drinking water quality. Measured values are shown in Table 3. Based Figure 3, for all Nine samples the concentration of copper decreases after LSP and IEP and RF. The concentrations of copper ion in ground water for various locations were given in table 4..Even though copper is an essential element inhuman diet but human eats and drinks copper approximately 1.00µg per day. It is also occur naturally in plants and animals. If the concentration of copper exceed 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 [15].

Iron (Fe):

Iron is the fourth most common element in the earth‘s crust [16]. 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 [19]. In the present study concentrations of Iron are well below the WHO Guidelines for drinking water quality. Measured values shows in Table 4.

Cadmium (Cd):

Cadmium is released to the environment in waste water, and pollution caused by contamination from fertilizers [14]. Generally, cadmium is found naturally in small quantities in water. Cadmium can be released to drinking water from the corrosion of some galvanized plumbing and water main water piping materials. The permissible limit for cadmium in Drinking water no exceed than 0.003Mg/L as per WHO. 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 4, for all samples the concentration of cadmium decreases after LSP and IEP, but it shows significant decrease in Cd Concentration after RF.

Lead (Pb):

Lead is common heavy metal found in industrial effluent, particularly in developing countries. The main source of Lead are 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 Cadmium is beyond the WHO guideline for all samples. The measured values shows in Table 3, from the graph it reveals that there is a decrease in concentration of Pb after LSP,IEP but after RF treatment concentration of Lead is decreases near to the permissible limits, which is shown in figure 4.Exposure to lead is very dangerous for young children compared to an adult. This is because young children's growing rate is much higher than an adult. Lead can accumulate in human body over some time and cause serious damage to brain, kidney, nervous and red blood cells. For infants, large amount of lead can cause delays in physical and mental development [19].

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 [20]. Manganese is present in all tissues of the body, the highest levels usually being found in the liver, kidney, pancreas, and adrenals [21]. As per WHO guideline the permissible of Lead in drinking water is 0.4mg/l.[14] In the present study concentrations of Manganese are below the WHO Guidelines for drinking water quality. Measured values shows in Table 4.

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. [22]. Although levels of zinc in surface water and groundwater normally do not exceed 0.01 to 0.05 mg/l, respectively [1]. 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 4. From the result it that the concentration of Zn decreases significantly after rhizofiltration.

Chromium (Cr):

Chromium is an important industrial metal used in diverse products and processes [25]. 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 concentration levels in all studied samples were below then WHO Standards. The concentration levels of chromium in all the samples are shown in Table 4.

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 [26].maximum allowable limit for Nikel as per WHO guidelines is 0.07mg/L. 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 4.

5. CONCLUSION

In the present study three methods were employed for the determination of physico-chemical parameter and heavy metals from the ground water. These methods are lime -soda process, ion exchange process and rhizofiltration technique The results obtained for the various parameters shows that pH, Temperature and Conductivity value are well within the permissible limit. TDS and Hardness of some samples beyond the permissible limits. Heavy metals like Cd, Pb exceed the limits laid down by WHO for all samples. From the result it is clear that after LSP and IEP concentration of heavy metal decreases up to certain level of all metal ions. But it shows significant decrease in concentration of metal ions after RF treatment 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 that the ground water needs treatment to reduce the TDS, Hardness and metal ion concentration. From the result it reveals that Rhizofiltrtion is very useful and eco-friendly technique to reduce metal ion concentration in ground water as compared to Lime-soda and Ion exchange process.

TABLE:3 Physico-chemical parameters of ground water samples of Purna river basin before treatment and after LSP,IEP and RF.

	Sample No.	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9
Temp(0c)	BT	24	24	24	24	24	24	24	24	24
	ALSP	25	25	24	24	24	24	25	24	25
	AIEP	26	26	25	25	25	26	24	24	24
	ARF	24	24	24	24	24	24	24	24	24
pH	BT	7.35	7.51	7.48	7.76	8.28	7.86	8.02	7.74	7.92
	ALSP	9.46	10.39	11.56	11.25	10.9	14.13	11.19	12.48	10.74
	AIEP	8.69	9.1	10	9.89	10.25	9.87	8.38	9.56	9.63
	ARF	8.06	8.15	7.93	8.3	8.31	7.85	7.91	8.07	8.27
TDS(mg/l)	BT	915	1190	2520	1550	1320	1050	413	1120	643
	ALSP	947	1190	2640	1600	1420	1570	413	1190	658
	AIEP	649	1000	2300	1410	1290	673	342	894	522
	ARF	866	1160	2470	1560	1350	1020	398	1080	637
Conductivity(Moh/cm)	BT	1.33	1.93	4.3	2.4	2.06	1.62	0.63	1.71	1.04
	ALSP	1.48	1.89	4.28	2.42	2.18	2.4	0.64	1.79	1.05
	AIEP	1.03	1.58	3.76	2.64	2.25	1.07	2.15	1.37	1.13
	ARF	1.38	1.88	4.41	2.5	2.09	1.66	0.63	1.79	1.04
Turbidity (NTU)	BT	7.2	5.4	6.2	8.4	9.3	4.7	5.5	11.9	5.7
	ALSP	11.9	8.7	7.1	11.2	6.5	5.8	5.1	12.3	7.8
	AIEP	0.7	2.4	4.9	4.8	3.2	3.4	2.7	2	1.9
	ARF	6.3	4.2	3.5	5.1	3.3	4.2	6.6	4.5	4.9
Alkalinity (PPM)	BT	342	396	396	738	756	306	306	252	360
	ALSP	270	252	72	486	666	270	180	126	258
	AIEP	360	540	1260	918	702	360	108	468	414
	ARF	288	324	306	702	720	270	270	216	360
Hardness (PPM)	BT	710	940	1650	510	130	900	350	940	460
	ALSP	5000	650	1000	310	320	850	210	640	300
	AIEP	400	660	1250	360	340	510	1000	660	390
	ARF	580	890	1520	490	390	820	320	920	140

Table: 4 AAS analysis of water sample for heavy metal before treatment (BT), after Lime soda process (ALSP), Ion exchange process (AIEP) and Rhizofiltration(ARF).

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
		ALSP	0.129	0.122	0.133	0.134	0.131	0.129	0.129	0.133	0.131	
		AIEP	0.119	0.117	0.129	1.118	0.123	0.121	0.117	0.119	0.124	
		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
		ALSP	0.157	0.156	0.157	0.157	0.155	0.155	0.156	0.157	0.154	
		AIEP	0.142	0.139	0.140	0.141	0.139	0.141	0.140	0.141	0.139	
		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
		ALSP	0.036	0.035	0.036	0.034	0.032	0.034	0.037	0.036	0.038	
		AIEP	0.029	0.029	0.027	0.024	0.027	0.025	0.029	0.027	0.029	
		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
		ALSP	0.044	0.046	0.041	0.042	0.047	0.040	0.044	0.041	0.046	
		AIEP	0.029	0.022	0.026	0.025	0.027	0.026	0.028	0.027	0.025	
		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
		ALSP	0.037	0.033	0.036	0.037	0.036	0.033	0.033	0.029	0.037	
		AIEP	0.026	0.024	0.026	0.025	0.024	0.025	0.024	0.022	0.024	
		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
		ALSP	0.039	0.037	0.034	0.038	0.032	0.035	0.039	0.037	0.034	
		AIEP	0.025	0.026	0.027	0.024	0.028	0.026	0.025	0.027	0.025	
		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
		ALSP	0.031	0.031	0.029	0.029	0.031	0.032	0.030	0.032	0.031	
		AIEP	0.024	0.020	0.021	0.022	0.021	0.019	0.021	0.025	0.022	
		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
		ALSP	0.039	0.037	0.039	0.036	0.038	0.035	0.037	0.039	0.033	
		AIEP	0.031	0.032	0.030	0.029	0.031	0.028	0.031	0.028	0.029	
		ARF	0.019	0.021	0.018	0.015	0.016	0.19	0.020	0.022	0.019	

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