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Evaluation of Dissolved Salts and Heavy Metals in Groundwater

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Abstract. It is believed that groundwater is naturally protected from the pollutants. However, it gets contaminated from percolation of dissolved salts and heavy metals associated with wastewater from the surface of the earth. The main purpose of the study was to assess the concentration of dissolved salts and heavy metals present in the groundwater. The amount of sodium and potassium was determined by flame photometer. Titration method is applied for the examination of other dissolved salts. Heavy metals were investigated by Atomic Absorbance Spectrophotometer. It was found from the analyses that the concentration of chlorides in the groundwater samples was five times higher than European Union guidelines values. The values of sodium, potassium, magnesium, calcium and sulfates were 5, 3, 2, 2 and 1 times higher than the standards respectively. The amount of heavy metals was low except cadmium, lead and nickel. Their results were 3.5, 2.5, and 1.1 times higher than World Health Organization Standards respectively. It was concluded that the groundwater quality was deteriorated by the percolation of dissolved salts and by two heavy metals namely cadmium and lead.

Keywords: Dissolved salts, Heavy metals, Groundwater pollutants, Water quality, Contaminants.

1 Introduction

Water is one of the most important commodities which man has exploited than any other resource for sustenance of a life. Though groundwater is believed to be naturally

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protected from pollutants, the layer of soil and particles of sand, gravel, crushed rocks etc, thought to act as filters, trapping contaminants before they could reach the ground water, yet pollution of water has emerged as one of the most significant environmental problems of the recent times [1]. The unique property of the water which makes it universal solvent and a renewable resource also make it a substance which by virtue of these properties has got a much greater tendency to get polluted [2]. Majority of water pollutants are however, in the form of chemicals such as salts and heavy metals remain dissolved or suspended in water [3]. Whereas, the wastewater contains bulk of nutrients which are useful for agriculture, it provide significant benefits to the farming communities in general but also impose negative impact on groundwater quality used for drinking purpose [4]. Although the harmful effects of saline and heavy metals contaminated effluent could be delayed for several years using heavy and intensive irrigation, but their adverse impacts on groundwater quality could not be checked or restricted due to percolation and leaching of dissolved salts and heavy metals [5].

Sodium is almost essential constituent of human dietary contents. The main source of sodium is sodium chloride used in cooking process and seasoning ingested foods contain additional sodium [6]. High concentration of sodium seriously worsens hypertension and cause of high blood pressure in later life [7], [8]. Potassium is used to balance electrolytic system of human body. Its deficiency may affect the renal system as well as heart and its excess intakes may cause hyperkalimia [9]. Calcium is biologically an important element presenting the bones and teeth of the body. Its deficiency may cause a disease called rickets. However, the higher concentration of calcium in groundwater causes hardness of water. Magnesium is vital element of human systems. It was found that high mortality regions had almost no magnesium in the drinking water. There is also a relationship between magnesium concentration of drinking water and cardiovascular mortality [10]. Carbonates and bicarbonates of calcium and magnesium are the basic cause of alkalinity and hardness of water [11]. Sulfates are present as dissolved impurities in sodium, calcium and magnesium salts in water [12]. Chlorides are present in mineral deposits, in sea and brackish water in ocean vapors and spray carried inland by the wind, and in human excreta. Chloride becomes objectionable due to adverse taste and deteriorates the domestic plumbing and water heaters and municipal wastewater equipment. It is suspected of being a contributor to hypertension [13]. Due to various implications of dissolved salts and heavy metals it was indispensable to analyze the groundwater quality used by the local population for drinking purpose. The prime objective of the study was to evaluate the concentration of dissolved salts and heavy metals present in groundwater that is used for drinking purpose.

2 Materials and Methods

The study was conducted near the waste stabilization ponds of Hyderabad city, where the wastewater was by passed to the agricultural land, used for cultivation due to the

shortage of the fresh water. Observation points were selected randomly. A total of three samples were taken from the same place for the average values of samples. Nitric acid was added to the samples for heavy metals to maintain their pH below 2, according to the standards set by World health Organization (WHO) and United States Environmental Protection agency (USEPA) [14]. The samples were preserved in a refrigerator at a low temperature of about 4oC. The investigation of salts and chemicals were carried out according to the standard methods set by WHO and USEPA. The methods of analysis for each parameter like sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), carbonates (CO_3), bi-carbonates (HCO_3), sulfates (SO4) and chlorides (Cl) as shown in Table 1.

Table 1 Instruments used and methodology applied for analytical purpose.

Parameters	Instruments/Methodology
Sodium	Flame Photometer
Potassium	Flame Photometer
Calcium	Titration Method
Magnesium	Titration Method
Carbonates and Bicarbonates	Titration Method
Sulfates	Titration Method
Chlorides	Titration Method
Heavy Metals	Spectrophotometer

The amount of heavy metals such as iron (Fe), manganese (Mn), copper (Cu), cadmium (Cd), chromium (Cr), lead (Pb), zinc(Zn), nickel(Ni), and cobalt(Co) were examined in the laboratory by Atomic Absorbance Spectrophotometer. Hitachi Model 180-50 Atomic Absorbance/ flame Spectrophotometer was used for analyses of groundwater samples. This instrument measures metal ions within wavelength range of 90-900 nm. Standard solution of each heavy metal e.g. iron, manganese, copper, cadmium, chromium, lead, zinc, nickel, and cobalt were simultaneously run in the concentration range of unknown samples on Atomic Absorbance Spectrophotometer. When a solution containing metal ions are introduced into a flame through aspiration, the metal ion through thermal dissociation converted into atomic vapors. When light beam is irradiated from hollow cathode lamp, atomic vapor in the base state absorbed only the spectrum where a wavelength is inherent to measured element, and state changed to exited state. The amount of intensity from spectrum to be absorbed is proportional to the number of atoms in the base state or concentration of metal ion. The concentration of heavy metals was determined by measuring the amount of spectrum absorbs accordingly. The instrument in various modes permits direct readout of concentration, integration (5, 10, and 20 seconds), measuring of peak height and determination of peak area. Analytical and measuring conditions, heating program, and analytical results were recorded in report format of 20 characters per line. Recording was made automatically.

3 Results and Discussions

Various dissolved salts make groundwater unfit for drinking purpose. Either their higher concentration causes hardness in water or makes the alkaline and brackish. The detailed results of salt concentration in analyzed groundwater samples is shown in Table 2 and illustrated in Fig. 1. The experimental results show that all salt samples showed higher values as compared with European Union guidelines. The maximum concentration of sodium was found 308, potassium 55, calcium 172, magnesium 192, carbonates 108, bi-carbonates 1515, sulfates 940 and chlorides 1058 mg/l. Their minimum concentration was 391, 21, 64, 52, 47, 197, 68 and 409 mg/l respectively. Only a few samples of potassium and sulfates show lower values than standards.

Table 2 Dissolved salt concentration (mg/l) in groundwater.

Parameters		Na	K	Ca	Mn	CO_3	HCO_3	SO_4	Cl
Results of Samples	Max:	1308	55	172	192	108	1515	940	1058
	Min:	391	21	64	52	47	197	68	409
	Mean	690	32	107	117	81	909	467	620
EU Standards		150	12	100	50	-	-	250	250

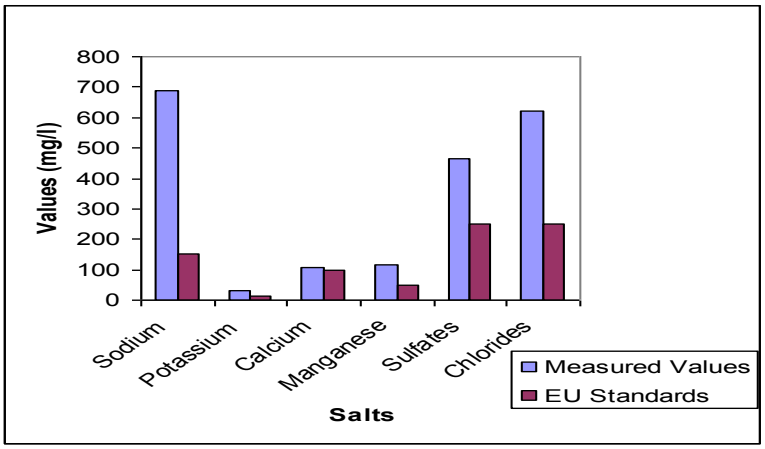

Fig. 1. Concentration of dissolved salts in groundwater vs EU Standards

The concentration of heavy metals in the examined groundwater samples is shown in Table 3, and graphically represented in Fig. 2 and 3. The amount of cadmium, and lead in the observed samples was found more than WHO standards. A few samples of manganese and nickel displayed higher values than standards. The remaining samples of manganese and nickel demonstrated lower values against standards. The concentration of the rest of heavy metals such as iron, copper, chromium and zinc was

quite low as compared with standards. The maximum value of cobalt was 0.012 mg/l with a minimum result of 0.008 mg/l in the examined samples.

Table 3 Heavy metals concentration (mg/l) in groundwater.

Parameters		Fe	Mn	Cu	Cd	Cr	Pb	Zn	Ni	Co
Results of Samples	Max:	0.223	0.113	0.019	0.018	0.013	0.04	0.068	0.086	0.012
	Min:	0.006	0.022	0.007	0.005	0.004	0.019	0.026	0.006	0.004
	Mean	0.078	0.087	0.012	0.019	0.009	0.025	0.047	0.022	0.008
WHO Standards		0.3	0.1	1	0.003	0.05	0.01	3	0.02	-

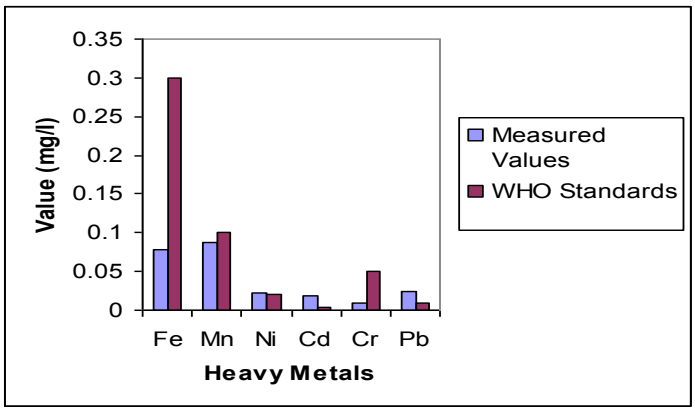

Fig. 2. Concentration of heavy metals in groundwater vs WHO Standards

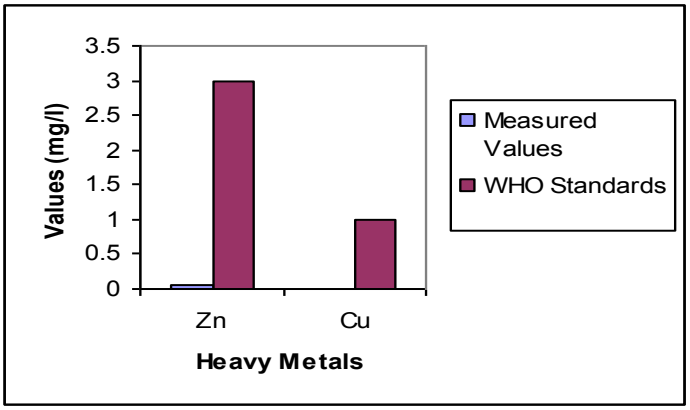

Fig. 3. Concentration of heavy metals in groundwater vs WHO Standards

It is revealed from the study of groundwater samples that the impact of heavy metals was not severe except cadmium and lead. However, their concentration may gradually get accumulated in the ground water over a period of time. They easily dissolved in water, and form aqueous solutions. The dissolved heavy metals cannot be separated by ordinary physical processes like screening, settling and filtration, but needs neutralization, oxidation, reduction, reverse osmosis and ion-exchange methods for their treatment.

4 Conclusion

It was found from the analyses that the concentration of chlorides in the analyzed samples was five times higher than European Union guidelines values. The values of sodium, potassium, magnesium, calcium and sulfates were 5, 3, 2, 2 and 1 times higher than the standards respectively. The concentration of heavy metals was low except cadmium, lead and nickel. Their results were 3.5, 2.5, and 1.1 times higher than World Health Organization Standards respectively. It was concluded that the groundwater quality was deteriorated by the percolation of dissolved salts and by two heavy metals namely cadmium and lead. The result of remaining heavy metals such as iron, manganese, chromium, copper and zinc were found normal.

It is suggested that wastewater if applied for agriculture purpose should properly be treated ahead of its application to the crops. It may cause leaching of dissolved salts and heavy metals to the groundwater. Consequently, it poses the possibility of various disorders in the population of the area, which are using groundwater for drinking purpose without its proper treatment.

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