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Research article

PHYSICO-CHEMICAL ANALYSIS OF GROUND WATER CONTAMINATION CAUSED BY INDUSTRIAL WASTE WATER IN FAISALABAD, PAKISTAN

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ABSTRACT: Water is guarantee of life on earth and its contamination is an emerging global issue. The present study was carried out at Ayub Agricultural Research Center Faisalabad to determine the ground water contamination caused by industrial wastewater and the quality of water used for drinking purposes. In two surveys, effluents samples and groundwater samples were collected from 3 different locations of selected site Jaranwala road, drain Khurrianwala industrial estate. Physical parameters included color, odor, taste, pH, electrical conductivity and total suspended solids and chemical parameters included nitrate and concentration of principal anions like chloride were determined. The pH and EC was measured by using portable, direct reading instruments. The value of nitrate of ground water samples were estimated directly by ion meter. The silver nitrate method was used for chloride determination. Alkalinity of water (carbonates and bicarbonates) was determined by titration method. The heavy metals content was estimated by atomic absorption spectroscopy. pH values of water samples ranged from (7.32-7.57) while the standard value set by WHO is (6-8.5). Electrical conductivity of ground water samples ranged from (3.32-3.98 dS m^{-1}), which is higher than the permissible limit set by WHO (3 dS m^{-1}). The carbonate and bicarbonates values of ground water samples were also within WHO standards. All drinking water samples have chloride concentration higher (17-25 meq L^{-1}) then the permissible limit set by WHO (7.04 meq L^{-1}). The Total suspended solids for drinking water samples were (2124-2515 mg L^{-1}) which were higher than standard values. The Nitrates present in drinking water samples ranged from (22.91- 44 mg L^{-1}) were within permissible to (50 mg L^{-1}). All drinking water samples have nitrate concentration in a permissible limit while the heavy metals content was in trace amounts. Overall result indicated that most of the parameters showed higher values than standards, which proved that industrial waste water damaging the quality of ground water (drinking water) adversely.

Key words: Carbonates, ground water, EC, effluent, pH, nitrates.

INTRODUCTION

Water is a basic necessity for our lives. Water has been ranked by experts as second only to oxygen as essential for life. We can exist without food for 2 months or more, but we can only survive for a few days without water [1].In spite of its significance, water is the most poorly managed resource in the world [2].Groundwater makes up about 22% of the world's supply of fresh water**.** Groundwater has emerged as an exceedingly important freshwater resource and its ever-increasing demand for agriculture, domestic and industrial uses ranks it as of strategic importance. Global estimates show that groundwater comprises one sixth of the total freshwater resources available in the world [3]. Many regions all over the world depend entirely on groundwater resources for various uses [4]. Population growth and the increase in demand for water and food supplies place an increasing stress on the groundwater quality and quantity [5]. In Pakistan, water availability per capita basis has been declining at an alarming rate. It has been decreased from about 5,000 cubic meters per capita in 1951 to about 1,100 cubic meters currently, which is just above the internationally recognized scarcity rate. It is projected that water availability will be less than 700 cubic meters per capita by 2025 [6]. The contamination of the water resources has been reported to be taking place as a result of number of anthropogenic activities including industrialization [7, 8] and agriculture [9]. The increase in demand for food supplies has been reported to be a major contributor to groundwater contamination due to excessive fertilization associated with cropping activities [9,10].

As a result rapid industrialization and agricultural activities, different types of contaminants including nitrates [9, 10, 11], sulphates [10], phosphates [12], hardness ions [13], total dissolved solids, chlorides [8] and heavy metals [13, 14], have been reported to cause the contamination of the water resources in different regions of the world. These contaminations have been reported to be due to anthropogenic activities resulting in point and non-point sources of pollution including fertilizers, sewerage, industrial effluents, animal wastes, organic manures and sewage etc. However, as a result of rapid industrialization and intensive agricultural practices, the water resources of Pakistan are being polluted. Among the industrial zones, Khurrianwala is well known for heavy industries and due to tremendous increase in industries and population growth, the demand for water is increasing every year. So, water purity must be assessed to determine its acceptability for human consumption. Keeping in view the importance of water, the present study was carried out to estimate the presence of different contaminants and determine the physicochemical characteristics of ground water at varying distances in relation to the effluent point.

MATERIALS AND METHODS

The present Study was conducted at the laboratory of Ayub Agricultural Research center Faisalabad for the analysis of water quality parameters. Sampling is the first essential step in assessing the quality of ground water. Grab samples were collected to highlight the conditions existing in ground water of Khurrianwla Faisalabad. Effluents samples and ground water samples were collected in plastic bottles after rinsing with distilled water and collected water 2-3 times. Samples were collected 2 times in the whole study and were estimated for Physical parameters such as color, odor, taste, pH, Electrical conductivity and total suspended solids and some chemical parameters such as nitrate and concentration of principal anions like chloride. The pH was measured with the help of pH meter (Model 1770 D). Then pH meter was calibrated to read 7 on the scale. The beaker containing distilled water was removed carefully and glass electrode was dipped into another beaker containing water sample. The deflection of readings was observed from rest position and when it was stable; the pH of sample was read directly and noted. The EC was estimated by Electrical conductivity meter (Microprocessor Conductivity Model DDS-120W) and same procedure followed for pH estimation.

Phenolphthalein alkalinity was determined by titration to the phenolphthalein end point and registered the total hydroxide and one half of the carbonates present. Total alkalinity was determined by titration to methyl orange end point, which included all the hydroxides, Carbonate and bicarbonate. Reagents which used are

Hydrochloric acid	0.1 N
Methyl orange indicator	0.1%
Phenolphthalein indicator	0.5%

The procedure for the determination of Phenolphthalein alkalinity 2-3 drops of phenolphthalein were added as indicator and swirled to mix the solution. A 50 ml burette was filled to the zero mark with 0.1 N HCL standard solutions. While swirling the flask, titrated the sample until the solution color was changed from pink to colorless. The volume of 0.1 N HCl standard solution used for titration was V_{pa} ml. Total alkalinity 2-3 drops of methyl orange indicator were added to the above titrated sample and swirled to mix. It was titrated with 0.1 N HCL standard solutions until color changed from orange to red. The volume of 0.1 N HCl standard solution used for titration was V_{ma} ml.

Calculation

Phenolphthalein alkalinity = $V_{pa} \times 0.1 \times 50 \times 1000 / 100$

$V_{pa} \times 50$

Total alkalinity = $v_{ma} \times 0.1 \times 50$

$V_{ma} \times 50$

The Silver Nitrate Method was used for chloride determination. 10 to 100ml of water sample was taken by pipette and transferred into 250 ml titration flask. Added 1.0 potassium chromate as an indicator and swirled the flask to mix. A 50 ml burette was filled to the zero mark with 0.1 N silver nitrate standard solutions. While swirling the flask, titrated the sample until brick red color appeared. The volume of 0.1 N silver nitrate standard solution used for titration was Va ml.

Calculation

Chloride (mg/l) = Va× 0.1× 35.45× 1000 / sample volume

Total suspended solid determined by EC value multiple with 640.

TSS (mgL^{-1}) = EC×640

The value of nitrate of ground water samples was estimated directly by ion meter. The electrodes were calibrated with standard solution of KNO_3 [15]. The value of heavy metals from ground water samples was estimated by atomic absorption spectroscopy (AAS 550).

RESULTS AND DISCUSSION

Physicochemical analysis of ground water (drinking water) indicates that industrial waste water was colored and having objectionable odor, whiles all the ground water samples were colorless, odorless and saltiest taste.

pH

The value of pH for effluent samples of survey 1 and 2 was almost same (9.18, 9.15) and there was no significant difference between 2 as shown in Fig 1. However, the pH values of grounder water samples at three distances are lower than that the effluents samples. At 100 ft distance pH value is higher but as the distance increase 200 ft to 300 ft the pH value decrease but there is no significant difference between the values at these distances during 1st survey. Same pattern was observed during 2ndsurvey.The values of ground water samples range (7.50-7.32). As shown in Fig. 1. The WHO standard value range (6-8.5) and the pH is more than 7 which represent basicity of water. These findings are in accordance with a number of studies indicating for the slightly basic pH values within the permissible limit in drinking water samples [16, 17, 18]. However, lower values of pH within permissible limit have also be observed in number of studies [19].

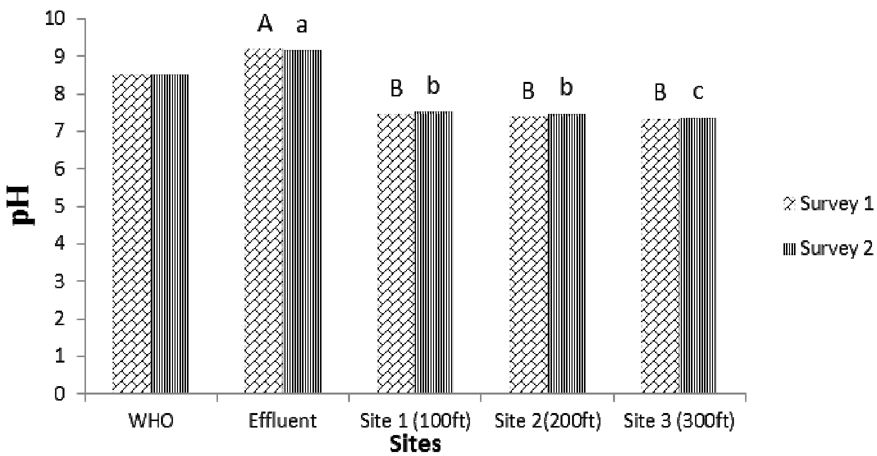

Figure 1: Comparison of pH values of both survey samples with WHO Standards. Values are means of three replicates. Means followed by same capital & small letters are not significantly different at P≤0.05 by using the Tukey test.

EC

The electric conductivity value of effluent during 1st survey (4.56 dS m^{-1}) was relatively lower than the 2nd survey (5.03 dS m^{-1}) value. The EC values of ground water samples during both surveys were decreased with increased distance (Fig 2). The WHO (World Health Organization) standard value for EC is 3 dS m^{-1} drinking water samples EC (electrical conductivity) range (3.32-3.98 dS m^{-1}) in both surveys, which is above the standard value. Overall results indicate that industrial waste water (effluent) affected the ground water. The result of the both surveys indicate that the effluents might have affected the EC value of the ground water samples with higher value of EC near the effluent point which carries on decreasing with increase in distance. Similar work done by [12]. Variation in EC values also be observed in number of studies [20], as shown figure 2.

Carbonate

The value of Carbonate (CO_3^{-2}) in effluent sample was significantly higher in 1st survey (30 $meqL^{-1}$) compared to the 2nd survey (10 $meqL^{-1}$) as shown in Fig 3. At the distance of 100ft away from the effluent site the CO_3^{-2} values of ground water samples (10, 3 $meqL^{-1}$) were lower than the effluent samples (30, 10 $meqL^{-1}$) value but the CO_3^{-2} value of ground water sample (10 $meqL^{-1}$) of 1st survey was higher than the 2nd survey (3 $meqL^{-1}$). Similar trend was observed at distance of 200 ft and 300 ft away from the effluent site.

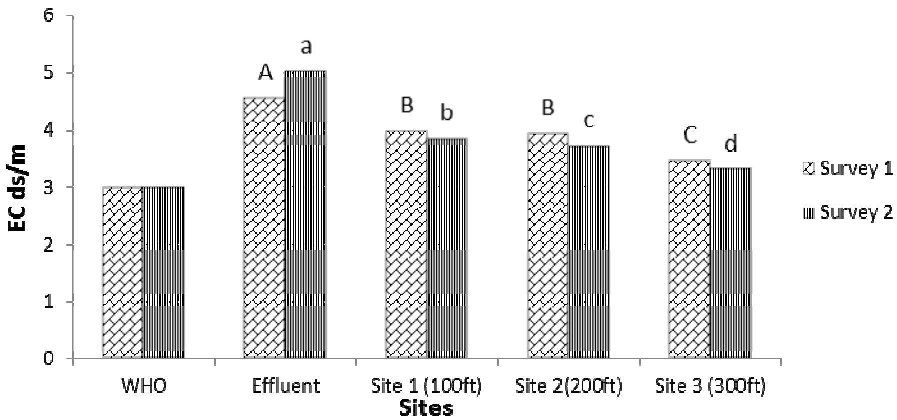

Figure 2: Comparison of EC values of both survey samples with WHO Standards. Values are means of three replicates. Means followed by same capital & small letters are not significantly different at P≤0.05 by using the Tukey test.

The both surveys values were decreasing with increasing the distances. As in figure 3, the Standard value for carbonate is 8.3 meqL^{-1}. Carbonate has already been reported to be estimated to evaluate the quality of drinking water supplies in a number of studies carried out in different regions of the world [17, 21].

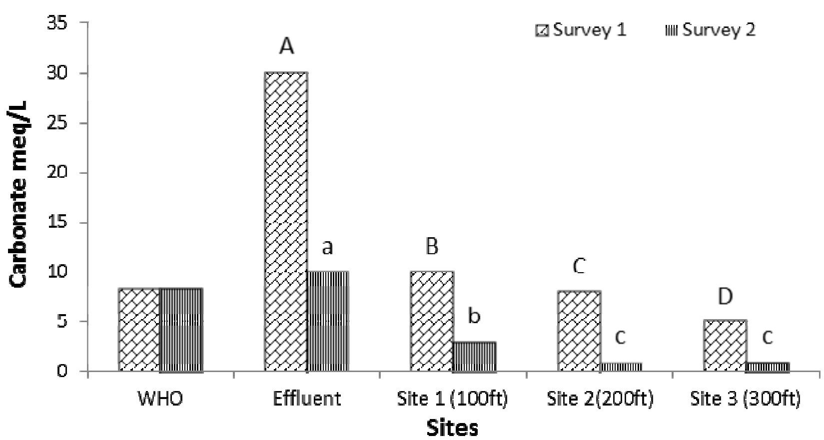

Figure 3: Comparison of carbonate values of both survey samples with WHO Standards. Values are means of three replicates. Means followed by same capital & small letters are not significantly different at P≤0.05 by using the Tukey test.

Bicarbonate

The HCO_3^{-1} (Bicarbonate) value of effluent sample in 1st survey (10 meqL^{-1}) was higher than the 2nd survey (5 meqL^{-1}). The values of ground water samples at 100 ft, 200 ft and 300 ft distance were lower than the effluents samples and decreases as the distance increase. . As in figure 4, the Standard value for bicarbonate is 8.3 meqL^{-1}. The values of ground water samples range (10 – 1.5) and within the permissible limit. The results of the previous study indicate that the effluents seem to have affected the carbonate and bicarbonate concentration in the ground water of the three selected sites. Carbonates and bicarbonate have already been reported to be estimated to evaluate the quality of drinking water supplies in a number of studies carried out in different regions of the world [17, 21].

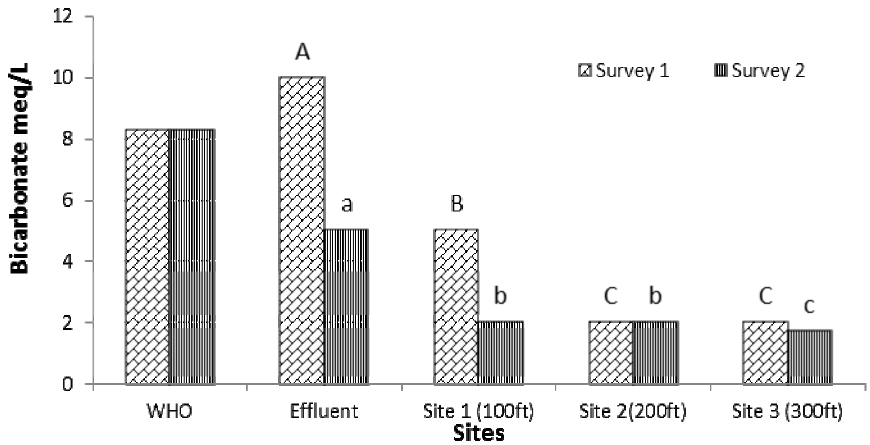

Figure 4: Comparison of Bicarbonate values of both survey samples with WHO Standards. Values are means of three replicates. Means followed by same capital & small letters are not significantly different at P≤0.05 by using the Tukey test.

Chloride

The Cl^- (chloride) value of effluent sample of 2nd survey (32.5 meqL^{-1}) was found to be higher than the 1st survey (20 meqL^{-1}). The values of ground water samples at three different distances were lower than the effluents samples and decreases as the distance increases from the effluent site.

The chloride values for ground water samples range (17- 25 meqL^{-1}). The permissible limit of chloride for drinking water according to World Health Organization (WHO) is 7.04 meqL^{-1}. All drinking water samples were shown the chloride concentration high then the permissible limit set by World Health Organization. These findings are in accordance with a number of previous studies indicating chloride values exceeded the limit value [22, 23, 24].Overall result shown that the chloride concentration is not in permissible range, which show that industrial waste water (Effluent water) percolate into the ground water and shows high values of chlorides, as shown in figure 5.

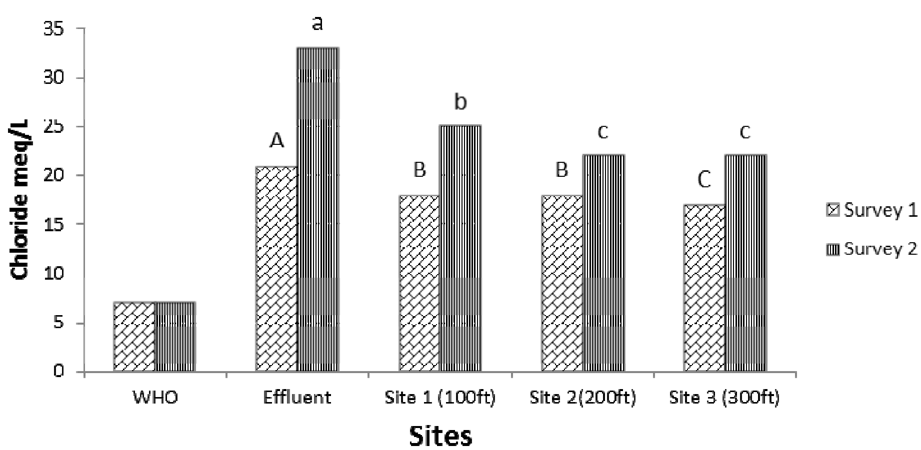

Figure 5: Comparison of Chloride values of both survey samples with WHO Standards. Values are means of three replicates. Means followed by same capital & small letters are not significantly different at P≤0.05 by using the Tukey test.

Total suspended solid (TSS)

As shown in Fig 6, the TSS (total suspended solids) value for effluent sample was lower in 1st survey (2918 mgL^{-1}) compared to the 2nd survey (3219 mgL^{-1}). During 1st survey the TSS values ground water samples were lower than the effluents. As distance increases from 100 ft to 200 ft, 300 ft the values of TSS in ground water samples decreases. Similar pattern was observed during 2nd survey.

The TSS values of ground water samples range (2547-2124). The WHO (World Health Organization) standard values for TSS 1000 mgL^{-1}.The result of this study indicate for the presence of relatively higher amount of TSS in the ground water samples as compared to that of recommended by WHO (World Health Organization). These higher values of TSS might be due to poor filtration during the pumping. Furthermore, the TSS values of the ground water samples were comparable with that of the effluents indicating that effluents might have affected the ground water samples at these sites. The high values of TSS already been reported in previous studies [13, 19, 24], as shown in figure 6.

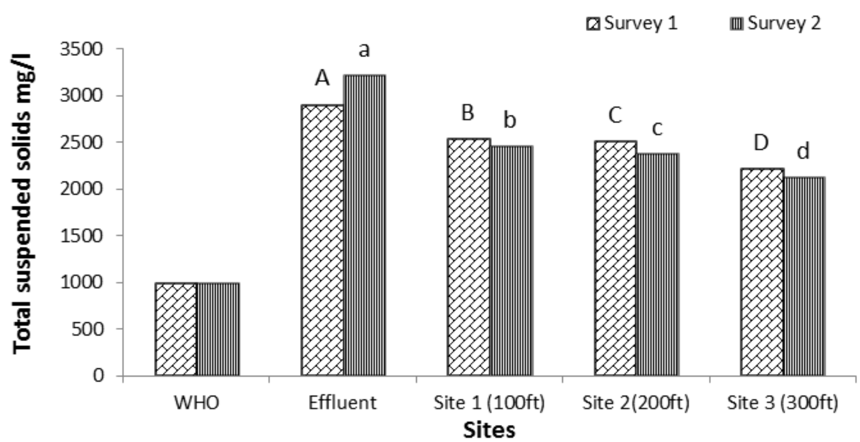

Figure 6 Comparison of TSS values of both survey samples with WHO Standards. Values are means of three replicates. Means followed by same capital & small letters are not significantly different at P≤0.05 by using the Tukey test.

Nitrate

As shown in the Fig, NO_3^{-2} (Nitrate) value of effluent sample of 2nd survey (282.5 mgL^{-1}) was found to be higher than the 1st survey (56 mgL^{-1}) value. The Nitrates were present in drinking water samples in a range of 22.91- 44 mgL^{-1}. These varying values were shown in Fig. 7. The permissible limit value for Nitrate according to World Health Organization (WHO) is 50 mgL^{-1}. So all drinking water samples have Nitrate concentration in a permissible limit. The Nitrate concentration was also found within the permissible limit in previous studies [17, 19].

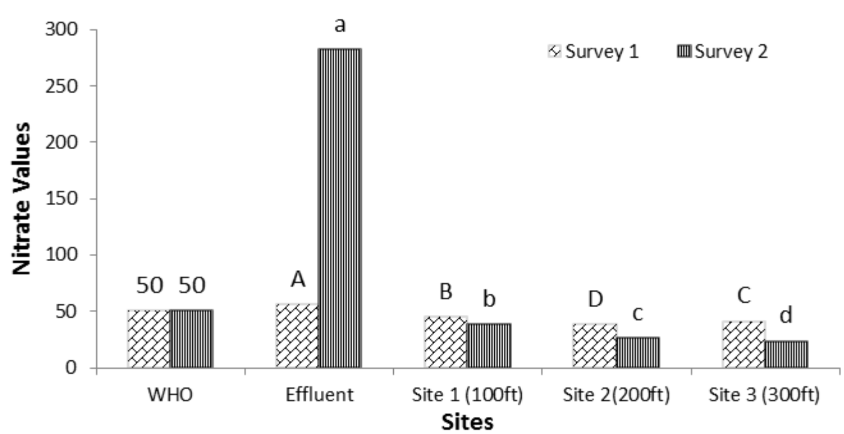

Figure 7: Comparison of Nitrate values of both survey samples with WHO Standards. Values are means of three replicates. Means followed by same capital & small letters are not significantly different at P≤0.05 by using the Tukey test.

Heavy metals

The heavy metals were determined by *atomic absorpion spectroscopy (AAS 550).*The result showed that heavy metals (Pb, Ni, Cd and Cu) in all water samples were present in traces amounts.

CONCLUSION

On the basis of result obtained in this study, it can be concluded that industrial effluents in Khurrianwala region are affecting ground water quality in nearby regions and making it unfit for domestic and house hold usage. To overcome this problem some remedial strategies should be implemented to preserve the safety of ground water.

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