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Impact of Industrial Effluents of Gadoon Amazi Industries over Quality of Ground Water: A Case Study

Musa Kaleem Baloch*, Arshad Ali, Gulrez Fatima Durani and Abdur Rahim

Department of Chemistry, Gomal University, Dera Ismail Khan, Pakistan

✉ musakaleem2001@yahoo.com

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Abstract: Installation of industries is a sign of development for a nation; however, due to poor management of waste material/effluents they are contributing otherwise and pollute the water we drink, air we inhale and the texture of soil we live at. In this article we have tried to correlate the deterioration of ground water by the industries installed in Gadoon Amazai, Swabi, Pakistan quantitatively. The groundwater samples from industrial area and outside it have been collected and analyzed for different parameters. The depth of sampling sources varied from 10 to 30 metres. Samples of effluents were also collected from different places from the effluents drainage over the period of one year and analyzed. The analysis of ground water and industrial effluents concluded that the ground water of the industrial area and the soil is very much polluted due to industrial effluents and the ground water is not fit for drinking purpose. Further, the effluents are highly polluted and not fit for irrigation purpose.

Key words: Ground water pollution, cations, anions, industrial effluents, irrigation.

Introduction

Main source of potable water in Pakistan is surface and ground water. Rivers and streams are the important surface water sources, while springs, deep and shallow wells are the common sources of ground water. The groundwater quality in Pakistan, normally improves with the increase in depth, as it is greatly protected from the pollutants added to water by the disposal of household and industrial wastewater. It is a known fact that the deficit or excess of different pollutants can cause serious problems in plant growth, animal and/or human health (Ferguson, 1990; Tiller, 1989). Therefore disposal of such material without purification can tremendously increase the health and environmental risk (Govindarajalu, 2003; Farid et al., 2005; Farid et al., 2006; Chen et al., 1997, 2008; Zhang et al., 2007; Cui et al., 2005). This issue is more severe in Pakistan where 60% of diseases are water-borne (Schroeder, 1960; Tihanssky, 1974) and the number of patients having gastrointestinal irritation, kidney and cardiovascular diseases are increasing with the time (Ellenhorn and Barceloux, 1968). However, on the other hand the industries and factories installed in Pakistan dump their solid and liquid wastes in sewer, nullahs (natural drains) and streams adjacent to them. The pollutants carried by the effluents later get mixed with groundwater and raise the level of heavy metals, beyond the recommended (Sial et al., 2006; Gulfraz et al., 1997; 2002). The situation is even worse in the adjoining area of Gadoon Amazi, Industrial Estate, district Swabi, North West Frontier Province, Pakistan where the untreated industrial effluent of about twenty different industries is used for irrigation purpose. The toxic material of the effluents is not only polluting the ground water used for drinking purpose by the workers and their families residing over there but also transferring into the soil. These pollutants can be further taken up to the animals and human beings through food material as vegetation is usually the first interceptor of heavy metals from the soil and water (Rauser, 1990; Wagner, 1993; Chaudhry et al.,

*Corresponding Author

1998; Zhang et al., 2007; Cui et al., 2005; Raghunath et al., 1999; Gallego et al., 2002; Cui et al., 2005; Mico et al., 2006; Facchinelli et al., 2001). These pollutants also deteriorate the quality of soil and reduce the agriculture production (Govindarajalu, 2003) whose sustainability is imperative for good yield (Dolenec et al., 2007; Wong et al., 2002). Further, the free movement of the effluent causes air pollution either through fermentation or getting dry and becoming part of air particulates which later on settle down in the cities especially in windy areas and involving the people in different diseases (Al-Khashman, 2004; Gibson and Farmer, 1986; Harrison et al., 1981; Li, Poon, and Pui, 2001; Sezgin et al., 2003; Thornton, 1991; Li et al., 2001). The suspended material in the effluents get settled with the passage of time and play the role of storing the pollutant and hence creating a threat to macro-invertebrate fish etc. (Schlekat et al., 1994; Pinel-Alloul et al., 1996; Peeters et al., 2000a, 2001; Van Griethuysen et al., 2004, Chappie and Burton, 1997; EPA, 2000; OECD, 2001; Den Besten et al., 2003; Peeters et al., 2001; Cole, 1979; Waldichuk, 1979). This paragraph concludes that the contamination of environment by the effluent of the industries is multidimensional and source of big risk for the living creature of not only this area but the whole world. However, up to now no one has tried to estimate the degree of contamination of ground water of the area and contribution of the effluents in it. Further to it one cannot generalize the situation/data from one to another case/situation, due to variation in geology of the soil/area and surrounding environment (Dolenec et al., 2007; Mitchell, 1974). It is therefore, need of the day to analyze the industrial effluents, of Gadoon Amazai industrial estate, groundwater of the area and away from it, so that an estimation of the degree of contamination of ground water of the area, role of effluents over it and to investigate the suitability of ground water for drinking and effluents for irrigation purpose.

Brief Description of Study Area

The study area (Gadoon Amazai Industrial Estate (GAIE)), which is comprised of Pre-Cambrian age rocks of the Salkhala, Manki, Sobra, Tanawal, Amber, Misri Banda and Panjpir Formation, granites and sills/dykes is situated on 34°:06:43 north latitude and 72°:32:92 east longitude at an elevation of 397 metres from sea level and 120 km by road from Peshawar in district Swabi, N.W.F.P., Pakistan (Anon 1992). The industries installed in this state, discharge their drain in the area and people use this water for irrigation up to some extent. However, the same industries are also polluting the ground water, air and soil by their waste in the area (WTC, TNAU and MSE, 2005).

Materials and Methods

Sampling and Analysis of Groundwater

Groundwater samples were collected with the objective to judge the quality and role of industrial effluents in their pollution and hence the sampling was performed from tube-wells, hand pumps and open wells. Among these sources, tube-wells are the deepest and covered, while the open wells are the shallowest and open ones. The sampling sites were selected reasonably away (uncontaminated) and around industrial (contaminated) area (Figure 1). The samples were collected in two-litre cleaned polyethylene bottles thoroughly. Twenty four water samples were collected from each source sites with the interval of one month. Immediately after the collection, the samples were analyzed for different parameters like pH, EC (electrical conductivity), hardness, total solids etc., soluble anions and soluble cations following the standard methods described in ASTM (ASTM 1993). The concentration of the metal ions was determined using Varian AA-1445 series Atomic Absorption Spectrophotometer (AOAC, 1984).

Sampling and Analysis of Industrial Effluents

Samples were collected in plastic bottles from different places of the collective drainage of the industrial effluents as stated earlier and analyzed for different parameters. Ten samples were collected every time from each sampling place and the sampling was carried out fortnightly over the span of two years. Immediately after the collection, the samples were analyzed for all the parameters mentioned for groundwater using the standard methods (US Salinity Lab. Staff, 1954). The concentration of the metal ions was determined by the above stated methods.

Results and Discussion

The values obtained for different parameters of groundwater samples collected from different sources located in uncontaminated area were as follows: The pH values varied from 6.88 to 7.29. Among these the greatest value is for the sample obtained from open well 3. The electrical conductance of the samples was in the range of 215-382 μS/cm, whereas the TDS values were 228-345 ppm, TSS values were below detection limit (BDL), TS 228-345 ppm; COD 0.24-6 ppm; NO_2^{-1} BDL; NO_3^{-1} 0.9-1.23 ppm; S^{-2} BDL; SO_4^{-2} 82.2-138 ppm; CO_3^{-2} 0.58-

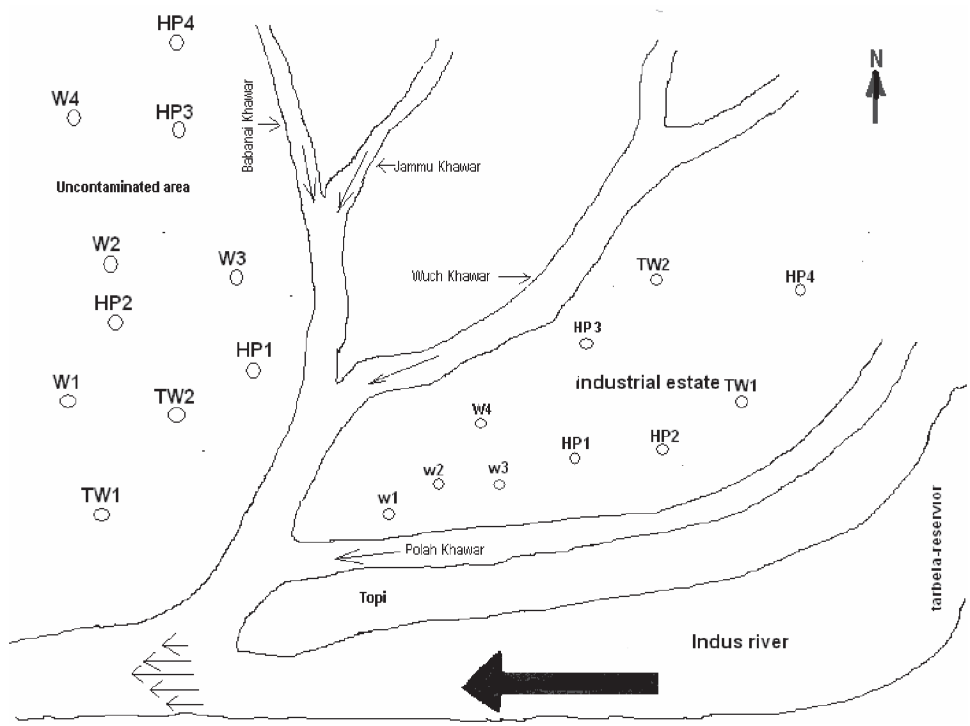


Figure 1: Schematic presentation of industrial area and flow passage of industrial waste.

1.1; HCO_3^{-1} 41-58.5 ppm; Cl^{-1} 80-98.5 ppm and hardness was 106-191 ppm. These results show that the values are within the permissible limit as compared to standard one (DeJohn, 1990) and very much dependent over the depth of the source.

The values of different cations obtained from various sources of groundwater located away from industrial estate shows that Na^+ value is 16.25-25.75 ppm, K^+ 3.3-6.6 ppm, Ca^{2+} 39-88 ppm, Mg^{2+} 62-87 ppm, Fe 0.14-0.25 ppm, Cu 0.80-1.6 ppm and Zn was 0.49-1.23 ppm. The concentration of Pb, Cr, Co, Mn, Cd, Ni and Ba were BDL. It can be noted that except Cu the values of all the parameters are within the permissible limits, concluding that the groundwater of the uncontaminated area (away from the industrial estate) is suitable for drinking purpose. High contents of copper may be due to the fact that the pipes used for pulling the water out of earth are made up of copper. The other conclusion which can be extracted from the data is that the samples obtained from open wells and hand pumps contain more contents of metal and nonmetal pollutants due to the reason that they are open and their depth is less, hence the industrial effluents including gases pumped in the atmosphere by the industries have polluted the ground water by simply leaching through the soil or otherwise.

The samples collected from different sources (open wells, hand pumps and tube wells) located in the industrial estate and named as contaminated area are also analyzed for the same parameters. The average values of samples collected from these sources are all on alkaline side having pH values 6.67-8.24, which is quite high as compared to standard one (John, 1990). Among these, the samples obtained through hand pumps have highest pH and that of tube-wells the lowest. This can be explained that during the flow of effluents towards river/ other main course or agricultural field, they percolate down the soil. However, during percolation some of the pollutants are absorbed by the soil and the rest pollute the ground water. The open wells or hand pumps are shallow hence easily accessible to pollutants carried out by effluents or gases pumped out by the industries which pollute the ground water. The electrical conductance of the samples 323.7-1248 µS/cm, TDS (425.5-1021.2 ppm), TSS (0-286 ppm), TS (426-1268 ppm), COD (1.35-22.37 ppm) and hardness (196.7-317 ppm) are also much higher than the permissible limit. The major cause of high values of pollutants seems to be the shallowness of the sample source (Figure 2).

The maximum and minimum values for cations are, NO^{2-1} (0.04-1.06 ppm), NO_3^{-1} (10.92-44.84 ppm), SO_4^{-2} (64.7-251.7 ppm), CO_3^{-2} (0-1.1 ppm), HCO_3^{-1}(77.2-277.7

ppm), Cl^{-1} (85.5-286.5 ppm) and all are above the recommended range for the drinking water. However, the value for sulfur (S^{-2}) was below estimation limit.

The average values obtained for metal contents are plotted in Figure 2. The figure shows that the concentration of all the metals [K (20.7-29 ppm), Ca (6.5-259 ppm), Mg (110-167 ppm), Pb (0-3.5 ppm), Cr (0-0.2 ppm), Co (0-2.47 ppm), Mn (0-3 ppm), Cd (0-0.84 ppm), Fe (0.15-0.25 ppm), Ni (0-3.3 ppm), Cu (0.1-2.6 ppm), Ba (0.13-2.94 ppm), Zn (0.6-1.5 ppm)] estimated in the groundwater obtained from the sources located in contaminated area are more than the permissible limit for drinking water except for Na (7.1-48 ppm). It can be concluded that the use of such water for drinking purpose is risky and can cause a number of diseases (Farid et al., 2005; Farid et al., 2006; 2006a). The results obtained from contaminated and uncontaminated sources are plotted in Figure 2 for comparison purpose. The figure gives clear indication that the samples obtained from contaminated area are heavily loaded by the pollutants and quite above the upper limit of standard.

The results obtained for all the parameters of the groundwater collected from the contaminated sources are plotted as a function of depth of the source taking the average depth for open wells, hand pumps and tube wells as 10, 15 and 30 m respectively (Figure 3). It is interesting to note that the contents of pollutants decrease as the depth of the source increases. The data give negative slope for almost every parameter and average value of slope and R^2 comes out as –4 and 0.4 respectively (Figure 3).

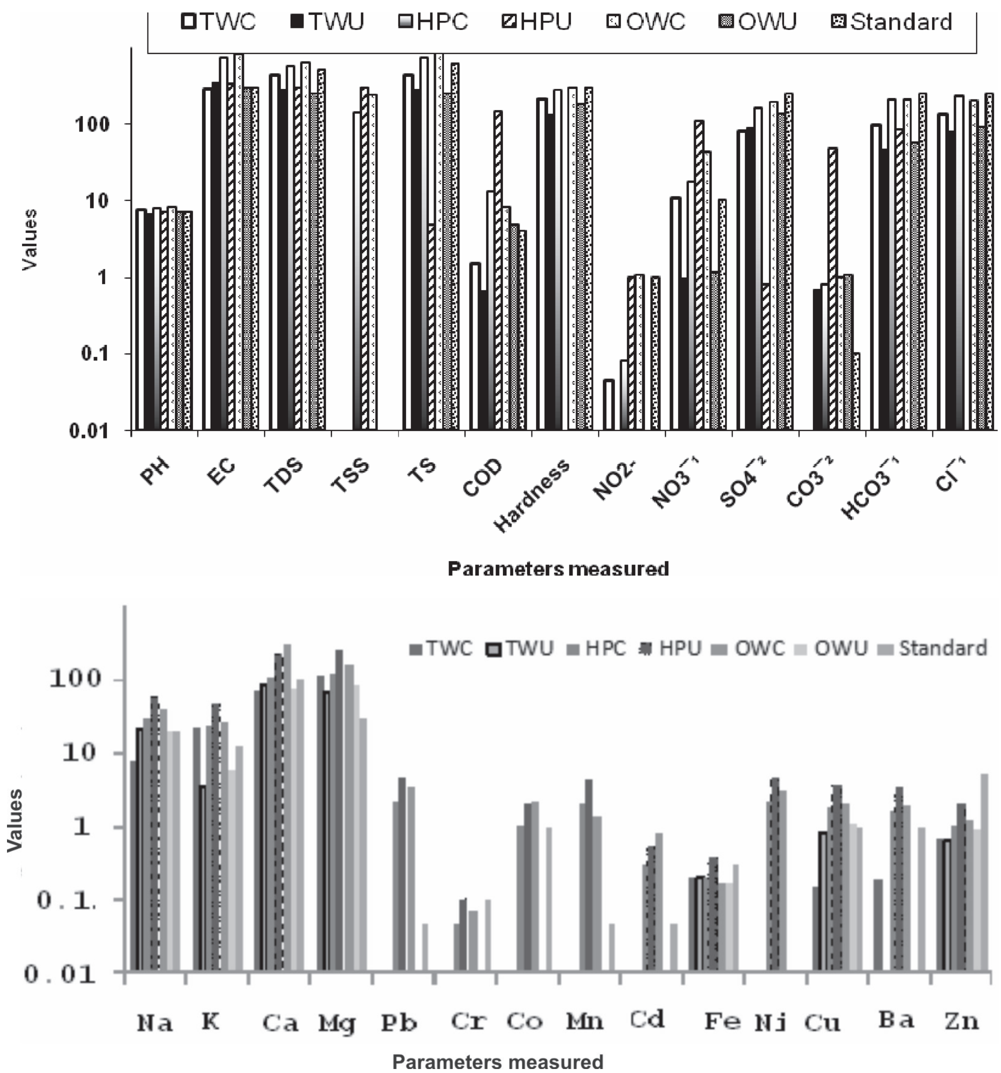


Figure 2: The average values of different parameters of ground water collected from contaminated and uncontaminated area. TWC and TWU stand for tube well located in contaminated and uncontaminated areas of industrial estate. Similarly, HP and OW stand for hand pump and open well.

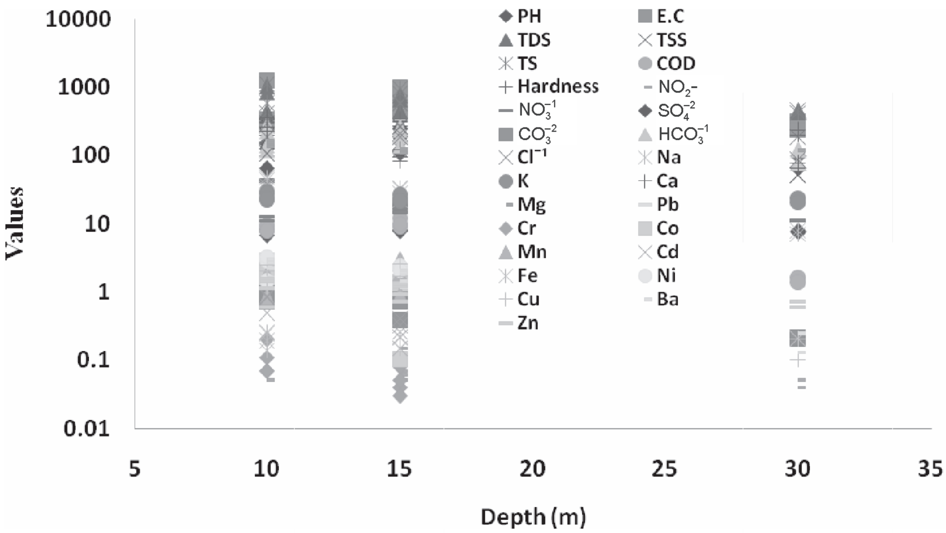
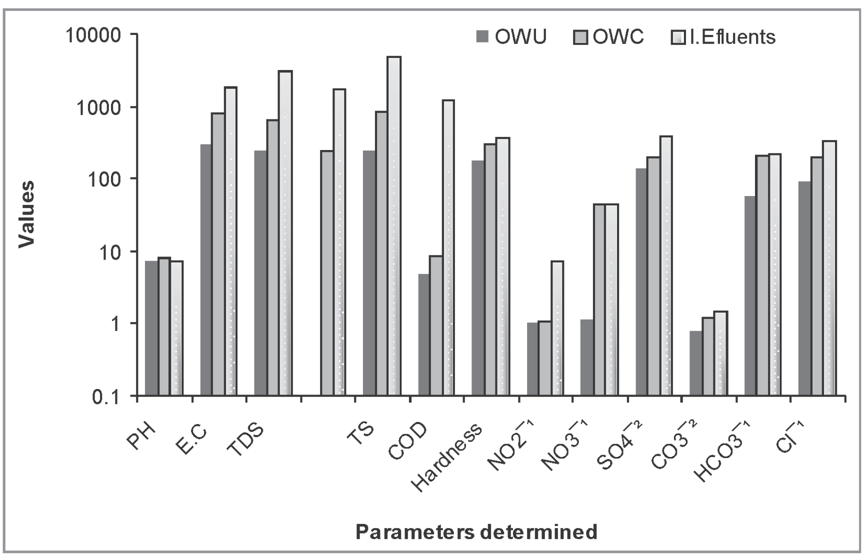


Figure 3: Values of different parameters of ground water collected from contaminated area as a function of depth of the source.



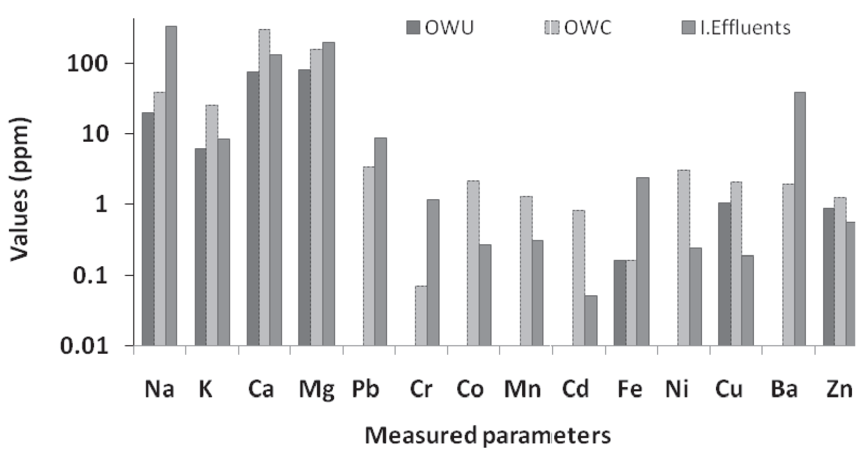


Figure 4: The values of different parameters obtained for open well uncontaminated (OWU), open well contaminated (OWC) and industrial effluents (I. Effluents).

These values are quite high to conclude that the values are depth dependent considering that a number of uncontrollable variables like texture of soil, history of soil etc. play considerable role in the phenomenon. We have also applied different statistical techniques to the data like one way ANOVA, correlation-Pearson and found good correlation among the parameters values and depth of the source. These observations give a good reason to conclude that the ground water of the industrial estate has been polluted only due to leaching down of the pollutants of the industrial waste.

The industrial effluents were also analyzed and found that all the parameters were having the values much more than permissible level recommended for irrigation. The average values of the pollutants available in effluents are plotted in Figure 4 together with the ground water obtained for uncontaminated and contaminated area of industrial estate. The figure signifies the relationship between the contents of industrial effluents and degree of pollution of the ground water. The statistical technique 2-way ANOVA was also applied whose results indicated the dependence of degree of pollution of ground water over the contents of the pollutants in the effluents. It is therefore concluded that the ground water is contaminated by the industrial effluents and not fit for drinking. Further the effluents are not suitable for irrigation purpose under such conditions and need purification before used for the purpose.

Conclusion

The analysis of ground water obtained from different sources located in the vicinity and away from industrial area is carried out. The results conclude that the samples taken in the vicinity of industrial area are contaminated by the pollutants carried out by the effluents of the industries. Further the samples obtained from deep sources are less contaminated and vice versa. The results obtained from the effluents show that these are not suitable to be used for irrigation.

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Contents