J. Ecophysiol. Occup. Hlth. 14(1 & 2) (2014) 1–6

Assessment of Groundwater Quality in Paper mill Effluent Affected Area in Moradabad region

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Abstract: *Released effluent form paper mill percolates though soil and slowly mixes with ground water aquifers. Water samples were collected from 5 sampling stations (S1, S2, S3, S4, S5) around the paper mill. Samples were analyzed for their water quality for various parameters. Statistical analysis was employed to evaluate the water quality for 5 monitoring stations. Water quality variables such as, TDS, Sulphate, Chloride exceeded WHO guidelines of drinking water. The pollution threat to ground water is from TDS, Sulphate and Chlorides, which are associated with pulp waste in the studied area. The study reveals that wastewater even from a single mill can affect the ground water quality of nearby area.*

Keywords: Groundwater, Paper mill effluent, Physico-chemical parameters.

Introduction

Pollution is the dark side of civilization and dumping of polluted material is a serious problem. Massive industrialization has resulted into massive quantity of effluent. The after effects of industrial effluents has reached to the bottom of soil i.e. up to ground water level, after deteriorating the quality of air and soil which is quite visible. Several authors have reported about the presence of contaminants in soils (Dhewagi *et al.,* 2000) and waters (Kolpin *et al.,* 1998) in various parts of globe, as in Nigeria effluent from refinery and petrochemical industry has rendered country's ground water at many places at unique vulnerabilities (Uzoekwe *et al*., 2011) and also in India (Srinivasa Rao, *et al*., 1997;Tamma Rao *et al*., 2013) Contamination of ground water is a serious problem faced by developing countries. Paper mills are one of the largest reliever of effluent. Pulping and bleaching during paper production requires lot of water, approximately 135 cubic meters for one tones of paper produced (Anon, 2001).

Since pulp and paper produced corresponds to only 40–45% of original weight of the wood, the effluent waters are heavily loaded with organic matter. PME contains huge amount of solids, organic matter, lignin, phenols, AOX (Adsorbable Organic Halides).It also contains huge amount of BOD, COD and considerable amount of heavy metals as well (Ali and Seekrishnan, 2001, Garg *et al*., 2007, Talukdar *et al.*, 2011). Although white rot fungi, certain bacteria and certain aquatic plants do naturally reclaimate the polluted sites by paper mill (Vidyarthi *et al*., 2011; Malik *et al.,* 2004) but that does not suffice. Certain authors have put forward the model of Assisted Natural Remediation" (Adrino *et al*., 2004), which includes soil amendments to accelerate the naturalprocess of remediation, which includes immobilization adsorption of contaminants, but on ground application is still awaiting. Industry continues to pollute the sites. Chlorine compounds used in bleaching plant of mill reacts with lignin and its derivatives results in the formation of chlorinated phenolic compounds which are recalcitrant and persist in nature for long

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time and high pollution load of effluent effected area pollutes the ground water (Senthilkumar *et al.,* 2011).

The high level of civilization related ground water pollution has recently become a major issue and the chemical analysis of water is important for environmental monitoring and legislation. ETP (Effluent Treatment Plant), an important safety measure, is not being installed in many of small paper mills due to economic reason. Untreated effluent causes huge pollution in all area of biosphere i.e. air, soil and ground water (Saxena, 1990). Degradation of ground water quality can be reported from deep percolation from intensively cultivated fields (Daniel *et al.,* 1990). The present study has therefore been conducted to assess the current status of ground water quality and to determine the effect of PME affected area near Moradabad, UP.

Materials and Methods

A total of 25 samples were collected from five different stations. Ground water samples were collected in 1000 ml bottle pre cleaned with distilled water. In order to assess the impact of effluent on ground water quality. The water samples were analyzed for physico-chemical parameters using the standard procedure (APHA 2005) and centaury water testing kit and spectrophotometer, pH, EC, TDS, and important cations such as Ca, Mg, Na, K. Besides this anion such as Cl, SO_4, NO_3 were also analyzed pH was measured by digital pH meter. Electrical conductivity was measured by conductivity meter. Sodium, potassium, calcium and magnesium were measured by flame photometer(Systronics128). TDS was measured by Hanna Pocket TDS meter. Before collecting water samples hand pumps and jet pumps were run continuously for some time to avoid any turbidity in water due to presence of fine mud and sand particles. In flame photometry hot flame evaporates the solvent,atomizes the metal and exciteselectron to an upper state (Na, K, Ca and Mg in present study). Light is emitted at characteristic wavelength for each metal as the electron returns to the ground state. Optical fibers are used to detect the emission wavelength monitored for the analyte species. Comparison of emission intensity with standard solution gives quantitative results.

The study area is located at Moradabad –Agra highway which is 32 km south to Moradabad. The area is polluted by the effluent released from the paper mill established there, i.e. Shakumbharistraw products private limited. Over all 25 samples were analyzed from 5 sampling stations selected near the paper mill effluent affected area during September 2011 to August 2012. Samples were collected from bore wells of 5 sampling stations. The area of samples collected includes; site 1, which was taken in Gopalpur village area, three kilometer far effluent channel. Site 2 was nearer to effluent channel. Site 3, site 4 and site 5 were approximately 1 kilometer far from each other in the vicinity of paper mill.

Results and Discussion

The descriptive statistics of the analyzed quality parameters were depicted in Table 1. The pH of ground water ranges from 6.5 to 8.1 and high pH in ground water indicates that it is alkaline in nature. Site 2 reported highest concentration of pH. Electrical conductivity (EC) in ground water varies from 210 to 1600 mmhos and showed a positive correlation with TDS (r = 0.568), nitrate (r = .524) . EC is an important parameter for determining the water quality. EC of water samples more than 1000 mmhos/cm were not suitable for domestic and human consumption (Trivedy and Goel, 1986). EC and Na play a vital role in suitability of water for domestic and irrigation purpose (Galleges *et al.* 1999). High content of EC in water creates a saline soil, whereas higher salt content in irrigation causes an increase in osmotic pressure of soil solution (Gupta 1999). The salts affect the soil structure and function permeability and aeration which affect the growth of plants. Total dissolved solids in ground water ranged from 100 to 2100 mg/g (Table 2).

Table 1 Mean value of all the groundwater samples. *n* = 5.

Parameters	Station 1	Station 2	Station 3	Station 4	Station 5
pH	6.96	7.44	7.82	7.20	7.40
EC	614.00	1048.00	774.00	722.00	478.00
TDS	714.00	1428.00	842.00	960.00	640.00
Na	107.00	204.00	135.00	74.00	119.00
K	13.20	16.20	12.20	12.20	12.00
Ca	64.00	93.00	130.20	77.00	72.00
Mg	50.00	66.00	54.20	22.00	22.00
Chlorides	228.00	386.00	308.00	238.00	254.00
Nitrate	51.80	77.00	37.00	50.00	46.00
Sulphate	235.00	322.00	178.00	220.00	206.00

EC = Electrical conductivity., TDS = Total dissolved solids, K = Potassium.

Table 2 Maximum and minimum values of all the parameters in all the samples, with mean and standard deviation.

Parameters	Min	Max	Mean	±SD
pH	6.50	8.10	7.388	0.507
EC	210.00	2000.00	742.00	344.81
TDS	100.00	2100.00	965.60	443.88
Sodium	32.00	210.00	124.60	52.57
Potassium	3.00	32.00	12.70	6.379
Calcium	40.00	138.00	85.87	26.844
Magnesium	10.00	70.00	41.16	19.41
Sulphate	100.00	420.00	239.60	80.435
Nitrate	24.00	110.00	52.70	18.907
Chlorine	90.00	420.00	220.60	76.75

EC = Electrical conductivity, TDS = Total dissolved solids, TS = Total solids, Cl = Chlorides.

As per TDS classification (Fetter, 1990), ground watercollected from site 2 comes under brackish type (TDS > 1000mg/ml). TDS showed positive correlation with sulphate (0.647) and Na (r = 0.723) as depicted in Table 3. Water from site 2, site 3 and site 4 contains TDS value 1442 mg/l, 842 mg/l and 960 mg/l (Table 1), respectively. Samples from site 2 falls under the category of brackish water which is not suitable for drinking purpose. High TDS value of water sample causes harm to live stock and adversely affects plant by increasing soil salinity (Galleges *et al*., 1999). High concentration of TDS in ground water may affect the persons who are suffering from kidney and heart diseases (Duggal, 1996). Bureau of Indian standards has prescribed maximum permissible limit for TDS in drinking water up to 500 mg/l. TDS showed positive correlation with EC (r = .568). The value of TDS, chlorides and sulphate at site 2 exceeded the permissible limits and indicates high pollution at site two which is close to effluent channel.

Table 3 Coefficient of correlation among different physico-chemical parameters of groundwater samples.

Parameters	pH	EC	TDS	Na	K	Ca	Mg	Chlorides	Nitrate	Sulphate
pH	1.00									
EC	0.176	1.00								
TDS	0.12	0.568	1.00							
Na	0.281	0.522	0.723	1.00						
K	–0.062	0.378	0.098	0.229	1.00					
Ca	0.417	0.186	0.178	0.37	0.032	1.00				
Mg	0.126	0.161	0.440	0.433	–0.17	0.409	1.00			
Chlorides	–0.130	0.485	0.6307	0.220	–0.32	–0.028	0.490	1.00		
Nitrate	0.031	0.524	0.315	0.279	–0.33	–0.028	0.228	0.078	1.00	
Sulphate	0.218	0.492	0.647	0.431	0.207	–0.16	0.116	0.125	0.742	1.00

EC = Electrical conductivity, TDS = Total dissolved solids, K = Potassium.

Potassium concentration ranged from 3 to 32 mg/l. Sodium concentration in ground water was found in the range of 32–210 mg/l and nitrate varies from 24 to 110 mg/l. High nitrate concentration could pose potential hazard to infant health. The consumption of water with high nitrate concentration decreases the oxygen carrying capacity of blood, causing blue babies syndrome ormethemoglobinemia (Jeevanandam *et al.,* 2006). Higher values of EC TDS, chlorides, Sulphates were recorded high from site two which is located near the effluent channel. It shows adverse effect of effluent on ground water. High concentration of chlorides (308 mg/l) was also reported at sampling site 3. Minimum concentration of almost all the parameters was observed at sampling site 1.

The correlation analysis between the parameters, i.e. TDS-EC, TDS-Na, TDS-Sulphate shows positive relationships (r = 0.568), (r = 0.723) and (r = 0.647), respectively (Table 3). Mg and TDS were moderately co-related (r = .485). Calcium showed negative correlation with chlorides (–0.028), nitrate (–0.028) and sulphate (r = –0.16). This indicates higher amount of chlorides nitrate and sulphate, which may be due to use of chlorine and sulphate during bleaching and pulping process of paper production technology. Co-efficient of correlation (r) was worked out to understand the relationships between the various parameters and to test the significance of model. It was considered to be not significant when the value of the probability of significance (p) was greater than 0.05. Means and standard deviation were calculated for each parameter.

High Ca content in water makes it unsuitable for human consumption. Mg content at site 2 (66 mg/l) and site 3 (54 mg/l) were higher which makes water unsuitable (>45 mg/l) for drinking (WHO, 1984). High calcium and magnesium makes water hard in nature. Generally calcium and magnesium maintain a state of equilibrium in most waters. More Mg present in water adversely affects the soil quality, renders the soil alkaline and decrease the crop yield (Rekha *et al*., 2004).

Senthilkumar *et al.* (2011) reported that Mg combines with sulphate and act as a laxative to human beings. Sodium an important cation occurs in all fresh natural waters (White *et al*., 1963). In present analysis high sodium content was reported at site 2 (204 mg/l). High sodium in water breaks soil aggregates and blocks the soil pores in irrigated fields. High level of potassium was reported in samples from site 3 and site

5 Chlorides were recorded high at site 2 (386 mg/l) which may be due to percolation of effluent containing high chlorides, used during bleaching. It is suggested in the present study that ground water in the paper mill effluent affected area is polluted for many parameters specially TDS, Chlorides and sulphates. Computational analysis of data set of hydrochemical constituents in the ground water suggests that the TDS is mainly controlled by chlorides and sulphates. Ground water from site 2 was found to have highest amount of TDS, chlorides and Na among other sites as site 2 was close to effluent channel suggests that effluent percolates down and pollutes the ground water. The study reveals that even one mill can pollute the groundwater of the adjoining area up to the distance of three kilometers. Use of this ground water may put the communities and crops at risk. An effective ETP operation is required to reduce the pollution effect and maintain the ground water quality.

Acknowledgements

One of the authors, Akhil Gupta (SRF, NET) expresses his sincere thanks to UGC for providing the necessary financial assistance for conducting the work. Authors are highly thankful to Research testing and calibration laboratory. Ministry of textiles, Govt of India Moradabad for providing us cooperation during testing and research work. Authors are also highly thankful to Dr. V. K. Tiwari, Head Department of Botany, Hindu college, Moradabad, for his invaluable guidance during the study.

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