Plant Archives Vol. 19 No. 1, 2019 pp. 1569-1571 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

ASSESSMENT OF GROUND WATER QUALITY AND ITS SUITABILITY FOR DRINKING IN INDUSTRIAL AREA JAJMAU, KANPUR, INDIA

Richa Gupta[1], Tanu Jindal[1], Ambrina Sardar Khan[1], Prateek Srivastava[2] and Ajay Kanaujia[3]

[1]Amity Institute of Environmental Sciences, Amity University, Noida (UP), India.
[2]Department of Botany, Chaudhary Mahadeo Prasad College, Allahabad (U.P.), India.
[3]Ganga Pollution Control Unit, Jal Nigam, Kanpur (U.P.), India.

Abstract

Kanpur City is a large industrial complex with nearly 800 industries. Several environmental pollution are causes due to these industries. The present study was carried out to assess the ground water pollution due to industries and also assess their Suitability for Drinking in different villages of industrial area Jajmau, Kanpur. The waste water from industries discharged with different types of pollutants is causing serious health problems in industrial area of Kanpur City due to improper treatment plants. These toxic pollutants affect the surface water as well as sub surface water and making it unsuitable for drinking and irrigation purposes due to leaching. Samples were collected during 2016-2017 (summer and winter) from hand pump in and around Jajmau, Kanpur. Samples were analyzed for physicochemical parameters and heavy metals. All analyzed data were compared with Indian standard specification for drinking water IS 10500-2012. The comparison of the data of ground water in different villages showed that TDS is very high which not only above acceptable limit, it is found above permissible limit in almost all sampling sites. Heavy metal like Chromium is also exceeding the acceptable limits in almost all sampling stations. Statistical analysis for two seasonal data of drinking water at ten villages, of industrial area Jajmau, Kanpur has been done and the results were discussed here. Groundwater is unfit for human consumption as it contains higher concentration of major ions and chromium. Contamination of groundwater causes the several water borne diseases.

Key words : Ground water, Waste water disposal, Contamination, physicochemical parameters, Heavy metals, Correlation.

Introduction

Water has been playing a major role in development of human civilization, Industrialization and urbanization. Over 97% of all the water an earth is salty and most of the remaining 3% is frozen in the polar ice caps (Bhattacharya *et al.,* 2012). Groundwater is an important natural resource. It is the largest reservoir of fresh water available on earth which is being continuously exploited due to increase in population especially in developing countries. Ground water is used for domestic, agriculture and industrial purposes in most of the part of the world (Karunakaran *et al.,* 2009). Contamination of water is increasing day by day. Keeping in view of the pollution effects and its risk management to the ecosystem, it is very essential to monitor the impact of industrial effluents on ground water quality (Agrawal *et al.,* 2016). Groundwater is the major source of drinking water in both urban and rural areas. Ground water has become a scarce commodity due to over exploitation and pollution of water. Groundwater provides drinking water for more than 80 cities. It is also used to irrigate crops, provide drinking water for stock and to support industry. Contamination of drinking water has become a major concern to the Environmentalist in the developing countries. Due to this pollution load sustained over long periods. Water is drawn from the ground for a variety of uses, principally community water supply, farming (both livestock and irrigated cultivation) and industrial processes (Chilton, 1996). Groundwater contamination can be classified as having either natural or anthropogenic sources. Natural groundwater contamination is mainly due to geological formation with shallow groundwater mass (water–rock interaction in cold waters), infiltration from low-quality surface water bodies (streams, rivers, lakes), seawater intrusion, or due to the effect of geothermal fluids (water– rock interaction in hot waters). Anthropogenic groundwater contamination is generally ascribed to extreme use of agricultural pesticides and fertilizers, mining wastes, disposal of industrial wastes, waste disposal sites, and imperfect well construction (Alper and Gokmen, 2011). Groundwater is natural source of our life support system. Ground water quality has become an important water resources issue due to rapid increase of population, rapid industrialization, unplanned urbanization, flow of pollution from upland to lowland, and too much use of fertilizers, pesticides in agriculture (Joarder *et al.,* 2008). Human and ecological use of ground water depends upon ambient water quality. In India, most of the population is dependent on ground water as the only source of drinking water supply (Murhekar and Krushna 2011). India accounts for 2.2% of the global land and 4% of the world water resources and 16% of the world population. It is estimated that one third of the world's population use groundwater for drinking (Pawari and Sagar 2015). Now days, the expanding danger to groundwater quality because of human action has turned into the matter of great concern. Presently a days the ground water potential and its Quality level in significant urban communities and urban focuses is getting crumbled because of the blast of population, urbanization, industrialization, disappointment of storm and inappropriate administration of rain water. Not just ground water, soil is additionally sullied by human and industrial activities due to dumping of solid waste and industrial effluent. Waste water is being used for the irrigation of edible plants and is a matter of concern due to the presence of pollutants particularly toxic metals (Barman *et al.,* 2000). The over exploitation of groundwater in some parts of the country induces water quality degradation (Mondal *et al.,* 2005). Contamination of drinking water may occur by percolation of toxics through the soil to ground water (Khan and Shivastava, 2012). Pollutant discharge causes widespread organic pollution, toxic pollution, and eutrophication, along with severe ecological destruction (Miao *et al.,* 2012). Approximately 190 million people fall ill and 60,000 people die from a range of other diseases and injuries associated with water pollution each year (Tao and Xin, 2014). Urbanization and industrialization in India has resulted in deep increase of generation of waste. Due to improper treatment and lack of awareness, waste water is not properly treated and disposed. Most of the industries discharge their effluent without proper treatment into nearby open pits or pass them through unlined channels resulting in the contamination of groundwater (Jinwal and Dixit, (2008). The problem is more crucial in rural cities due to cluster of industries. The strong waste produced from enterprises is being dumped close to the industrial facilities, is subjected to response with permeating precipitation water, and achieves the ground water level. Which make the issue of ground water contamination in a few piece of the nation. Both surface and subsurface water sources are getting polluted due to developmental activities (Chandra *et al.,* 2014). Industries are responsible for water pollution. Pollution in the soil and water has a lot of adverse effects and thus is of great concern to the public health agricultural production and environment health. Treated Industrial and domestic waste water is being used for the irrigation of the agricultural land which contributes significantly towards the contamination of the soil in wastewater receiving area (Sinha *et al.,* 2006).

In India, The province of Uttar Pradesh alone in charge of more than half of poisons entering in the river stream because of partially treated effluent drained into river and also used for irrigation. In Uttar Pradesh, Kanpur is biggest mechanical and business focus. Kanpur is one of the important industrial centres in northern India, where more than 800 industries are involved in manufacturing. Kanpur is most contaminated city as a result of huge number of tannery businesses is built up. It is otherwise called Leather city. Pollution becomes acute when tanneries are concentrated in clusters in small area like Kanpur, India (Beg and Ali, 2008). The large number of industries has clearly contributed to the economic growth of Kanpur. The tannery business mushrooming in north India has secured the Ganga River into a dumping ground. Kanpur is one of significant tannery bunch with generation of around 1000 tons of raw materials per day. In Kanpur mainly Jajmau area is home to biggest leather tanneries, footwear, and manufacturer and leather goods. The industrial area of Jajmau Kanpur having more than 400 tanning industry. 99% of industries are performing chrome tanning process. In tanning process dangerous gushing produced, which require exact care in treatment of effluent. Tanneries process is totally based on chrome tanning. It has been established that a single tannery can cause pollution of ground water around a radius of 7 to 8 km (Central Leather Research Institute (1990). Basic Chromium sulphate is used as Tanning agent. In tanning process, harmful toxic waste water generated, which require exact care in treatment of emanating. This toxic waste water, treated or partially treated is also being use for irrigation purposes. As per an estimate, about 80-90% of the tanneries use Chromium (Basic Chromium Sulphate) as a tanning agent. Chromium has many industrial uses and its unregulated application has led to the contamination of soil, sediments, surface and ground water (Barnhart, 1997; Kotas and Stasicka, 2000). It also contains chiefly chromium salts, copper, magnesium, iron, cadmium and arsenic salts when it discharged into the rivers it greatly affects the aquatic ecosystem Various chemicals used in tanning include lime, sodium carbonate, bicarbonate, common salt, sodium sulphate, Chrome sulphate, fat liquors, vegetable oils and dyes. Much waste water in urban areas discharges to ground (Ravenscroft, 2003). The treated tannery effluent is being used for irrigation nearby area which is 1800 hectare, covered different villages. There is CETP operating for treatment of tannery waste water but due to old technology and lack of knowledge, the CETP is not successful. This area is being irrigated with tannery effluent for last four decades which ultimately lead to ground water contamination. Due to large number of tanning industries, surface water as well as ground water quality is polluting continually by leaching of effluent which is mainly uses for irrigation purposes. Industrial effluents from leather tanneries discharged untreated, if allowed to Percolate into soil to ground water for a prolonged period seriously affect soil profile and the ground water table of the locality and make it unfit for drinking, irrigation and for general consumption Hence, it is important to know the quality of groundwater because it is the major factor which decides its suitability for domestic, agriculture and industrial purposes (Raju *et al.,* 2009). Many investigations have been conducted on anthropogenic contaminants of ecosystems Heikka, (2007) and reported that drinking water quality is affected by the presence of different soluble salts (Sonawane and Khole, 2010). So the objective of the study is to assess the Ground Water quality and their Suitability for Drinking in reference of physical and chemical properties and also to know the heavy metal contamination like Cr, As and Pb in industrial area Jajmau, Kanpur. The quality of ground water has been assessed by comparing each parameter with the standard desirable limit of that parameter in drinking waste.

Scope of study

Long-term disposal of tannery wastes has resulted in extensive contamination of agricultural land and water sources in many parts of India. The tannery industry mushrooming in North India has converted the Ganga River into a dumping ground. The untreated or partial treated industrial effluent discharge is increasing day by day and polluting the soil as well as ground water through percolation. In Jajmau industrial area of Kanpur city having one CETP and two STP since 1995 (36 mld UASB Tannery waste water Treatment Plant,130mld ASP Sewage Treatment Plant, 5 mld UASB Sewage Treatment Plant). The ground water has been contaminated possibly due to use of Effluent for irrigation.

Materials and Methods

Study area

The study area, Jajmau is one of the major regions in Kanpur district, Uttar Pradesh, India. Kanpur is house of small and medium scale industries which are producing a large amount of industrial waste. It is situated on the left bank of Ganga River and the right bank of its tributary, Pandu River (Gowd Srinivasa *et al.,* 2010). The district Kanpur lies between 800 21" East longitudes and 260 28'' North latitude. Jajmau is a chronic polluted area and one of the biggest exporting centers of tanned leather. The treated and untreated wastewater is being used for the irrigation from last two decades which covers 1800 acre land including near 10 villages. The distance between treated effluent channel and villages is 0.5 km to 10 km.

Sampling Locations

The present study was carried out at the different locations of Jajmau area of Kanpur city. The locations of sample collection were near the industrial area. The site for the sampling was identified which mainly used for domestics purposes. Total two sampling were done in year 2016-2017. One summer and one was winter samplings were done. Ten sampling stations were selected for the collection of ground water for this study in year June 2016 and January 2017. I had selected main villages of tannery industrial area of Jajmau which are located besides of effluent channel from distance of 0.5 to 10 km. Ground water samples were collected from selected locations in year 2016-2017 in seasons (summer and winter) from ten different selected villeges which were located along the effluent channel where effluent water is being used for irrigation purposes. 10 samples from 10 identified locations namely as Sekhpur (L1), Jana (L2), Motipur (L3), Kishanpur (L4), Madarpur (L5), Movaiya (L6), Kulgao (L7), Trilopkpur (L8), Allolapur (L9), Rooma (L10). All sampling sites of ground water along effluent channel with the aim of assessing the drinking water Quality has been illustrated in Fig. 1.

Sample Collection and Analysis

The ground water samples were collected from different hand pump of Jajmau villages along the effluent channel within the study area. The method described by APHA 22nd Edn 2012 were followed during field and laboratory work. Ground water samples were collected in plastic cans. All the sampling cans were cleaned with diluted HNO_3 then rinsed with tripple distilled water and also rinsed with ground water to be sampled. After collection of sample, some parameters like Temperature,

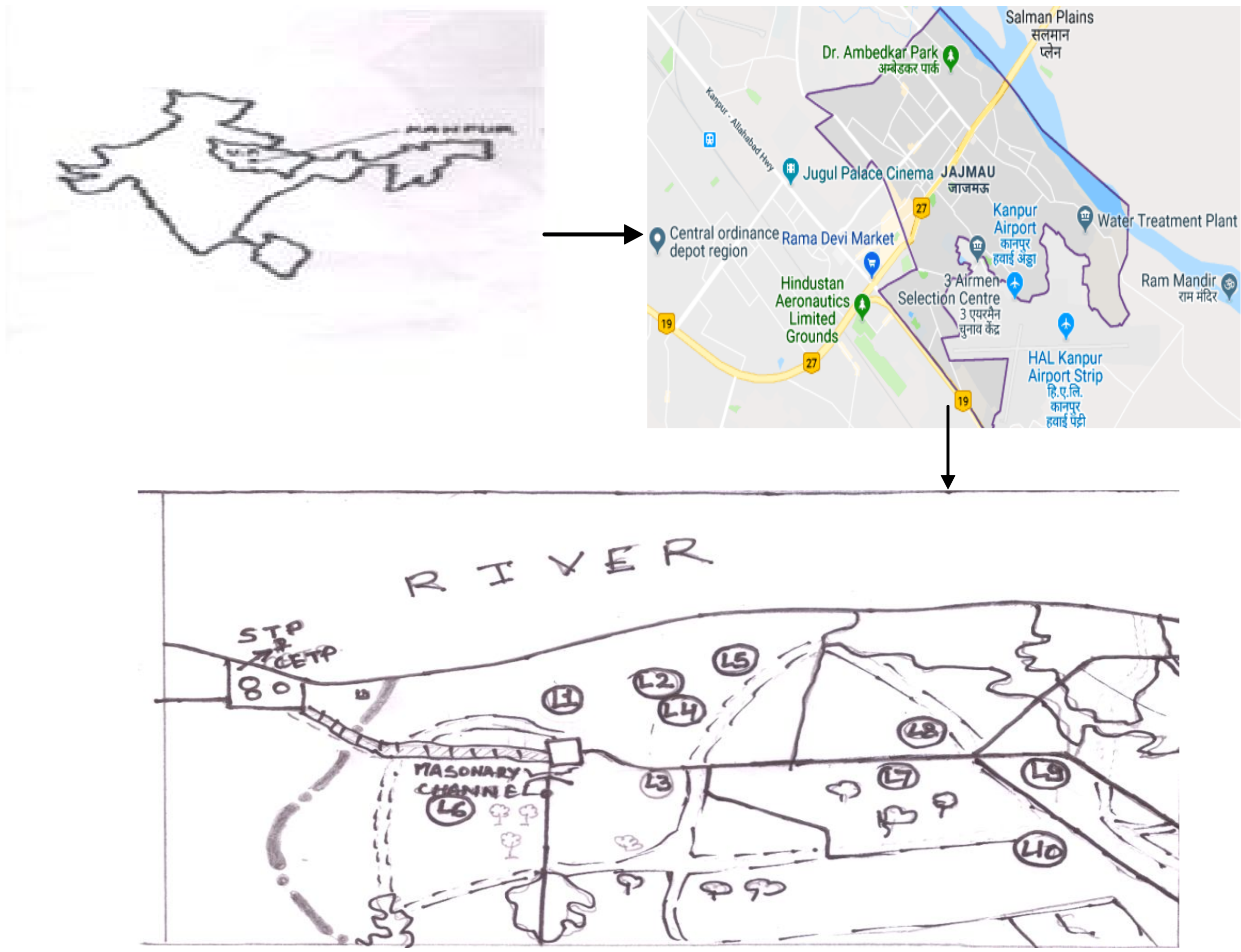

Fig. 1: Showing different Sites of Ground water (L1-L10) at Industrial Area Jajmau, Kanpur, Uttar Pradesh.

pH, Electrical conductivity (RI) was determined immediately on sampling site by portable digital meter. After that sampled were preserved in ice box and transported to the laboratory for further analysis like chemical and Heavy metals analysis. They were analyzed within a short period of time to get more reliable analytical results.

In ground water, Parameters were Total Dissolved Solids, Total Hardness (as $CaCO_3$), Calcium (Ca), Magnesium (as Mg), Total Alkalinity (as $CaCO_3$), Chloride (as Cl) Nitrate (as NO_3), Sulphate (as SO_4), Fluoride (as F), Total Chromium (as Cr), Arsenic (as As) and Lead (as Pb). The drinking water quality depends on many physicochemical parameters and their concentrations, which are derived from laboratory tests of water samples (Heydari and Abasi, 2013). The samples were analyzed for different physicochemical properties and heavy metals as per the Standards methods outlined in APHA 22nd edn 2012 (APHA, 1998) as well as IS 3025 with different parts. Total Dissolved Solids, Total Hardness, Calcium, Magnesium, Total alkalinity, chloride, Fluoride analyzed by titrametric method, analyzed by gravimetric method as well as pen type meter, Nitrate, Sulphate, were analyzed by Ultra violet Spectrophotometer (Make-Shimadzu, Model-UV 1800, Range-190-1100 nm), and heavy metal analysis done by ICP-MS make by Agilent. For the comparison of analyzed concentration of ground water with standard acceptable limits. Drinking water standard limits given by Indian Standard 10500-2012.

Correlation coefficient

In statistics, Correlation is a technique which can show relationship between two or more variables. In water quality it is used for the measurement of the strength and statistical significance of the relation between two or more parameters (Mehta, 2010). Correlation analysis measures the closeness of the relationship between chosen independent and dependent variables. If the correlation coefficient is nearer to +1 or –1, it shows the probability of linear relationship between the variables x and y (Sudhakar *et al.,* 2010). In this study, the relationship of water quality parameters with each other in the data of water analyzed was determined by calculating Karl Pearson's correlation coefficient, R, by using the formula as given below:

$$R = \frac{\sum(x-\bar{x})(y-\bar{y})}{\sum(x-\bar{x})^2 \sum(y-\bar{y})^2}$$

Where, x (x =values of x-variable, =average values of x) and y (y =values of y-variable, =average values of y) represents two different water quality parameters. If the values of correlation coefficient 'R' between two variables x and y are fairly large, it implies that these two variables are highly correlated. X Y (Sudhakar *et al.,* 2010).

Experimental Result and Discussion

Ground water quality assessment was done to determine its suitability in terms of drinking purposes. Concentration with limits followed by IS 10500. The results of the physio chemical analysis of ground water samples of hand pumps in industrial area of Jajmau are presented in Table 1 & 2 and Table no 4 & 5 shows that shows that the Pearson Correlation coefficient (r) matrix between physicochemical parameters of Ground water, Jajmau, Kanpur The quality of water resources depends on the management of anthropogenic discharges as well as the natural physicochemical characteristics of catchment areas (Efe *et al.,* 2005).

Temperature is a important parameter of ground water. Temperature was found between ranges 21-23^{0}C in june 2016 and 18-23.2^{0}C in January 2017. The increase in temperature decreases the portability of water because of elevated temperature carbon dioxide and other volatile gases which impart taste are expelled (Karunakaran *et al.,* 2009). The maximum temperature 23^{0}C in L5 in June 2016 and 23.2^{0}C was found on site L3 in January 2017. Temperature has positive correlation with EC and TDS. pH is also an important ecological factor and provides an important piece of information in many types of geochemical equilibriums or solubility calculations (Shyamala *et al.,* 2008). The pH value is an important index of acidity or alkalinity. In the present study pH ranges from 7.5-8.01 in June 2016 and 7.21-7.61 in January 2017, which lies in the range prescribed by IS 10500-2012. For the numerical values of correlation coefficient, R for the water quality parameters was given in Table 3. It is shown that a single parameter analyzed has relationship with other parameters. Highly positive correlation is observed between EC and TDS (R=0.83) in January 2017 and R= 0.995 in June 2016, between Ca 2+ and TH (R=0.960) and R= 0.866 in June 2016. Electrical conductivity of water is a direct function of its total dissolved salts (Harilal *et al.,* 2004). The average range of electrical conductivity from all ten sites was recorded 2470.8 µs/cm in June 2016 and 2473.2µs/cm in January 2017. The maximum and minimum conductivity was found 3735µs/cm and 1390 µs/cm on site L3 and L8 in the year June 2016 and in January 2017 maximum was 3830 µs/cm on site L3. Higher the value of dissolved solids, greater the amount of ions in water (Bhatt *et al.,* 1999). The level of TDS is one of the characteristics, which decides the quality of drinking water. In the present study, Maximum TDS was found on L3 site *ie* 2835mg/L and 2581 mg/l in both season and according to Indian standard 10500-2012, total dissolved solid values for

Table 1: Physicochemical parameters of drinking water from Industrial Area Jajmau, Kanpur, June 2016.

	Temp	pH	EC	TDS	TH	Ca	Mg	TA	Cl	NO_3	SO_4	F	Cr	As	pb
L1	22	7.8	2950	2286	1195	261	134	489	683	76	265	2.6	0.02	0.004	0.001
L2	21	7.6	2515	1985	995	220	110	395	580	54	210	1.7	0.05	0.003	0.0001
L3	22	8.01	3735	2835	1380	412	155	502	905	84	345	3.2	0.06	0.008	0.005
L4	23	7.5	2935	2285	1156	235	139	434	545	59	235	2.1	0.01	0.0002	0.001
L5	23	7.6	2310	1725	1075	257	112	337	375	68	220	0.8	0.021	0.003	0.002
L6	22	7.7	1810	1445	856	200	88	324	265	51	139	0.99	0.02	0.0005	0.0002
L7	22.5	7.65	2410	1950	1010	244	98	329	585	57	168	0.67	0.004	0.002	0.004
L8	23	7.7	1390	1150	710	177	90	321	261	49	125	0.56	0.029	0.001	0.002
L9	22	7.7	1643	1256	645	196	49	372	315	47	115	1.5	0.008	0.004	0.006
L10	23	7.6	3010	2397	1325	325	167	470	535	67	320	2.9	0.1	0.006	0.008
Mean	22.35	7.68	2470.8	1931.4	1034.7	252.7	114.2	397.3	504.9	61.2	214.2	1.70	0.032	0.0031	0.0029
Min.	21	7.5	1390	1150	645	177	49	321	261	47	115	0.56	0.004	0.0002	0.0001
Max.	23	8.01	3735	2835	1380	412	167	502	905	84	345	3.2	0.1	0.008	0.008
SD	0.66	0.14	719.22	540.90	244.25	69.81	35.38	71.60	204.48	12.23	79.54	0.96	0.03	0.002	0.00269

*Except Temp (^{0}C), pH and EC in (µs/cm) remaining all Parameters are in mg/l.

Table 2: Physicochemical parameters of drinking water from Industrial Area Jajmau, Kanpur, January 2017.

	Temp	pH	EC	TDS	TH	Ca	Mg	TA	Cl	NO_3	SO_4	F	Cr	As	pb
L1	20	7.61	3120	2510	1130	235	139	425	836	71	185	1.8	0.13	0.009	0.001
L2	22	7.52	2835	1615	910	245	117	370	532	53	154	1.4	0.06	0.005	0.003
L3	23.2	7.29	3830	2581	1360	315	145	378	805	83	234	2.9	0.05	0.002	0.006
L4	22.5	7.49	2578	1870	890	219	120	342	450	70	207	2.9	0.053	0.004	0.0002
L5	22	7.54	2475	1790	881	204	103	314	510	58	125	1.1	0.041	0.0001	0.0006
L6	20	7.55	1880	1949	670	170	105	307	310	40	138	0.61	0.016	0.002	0.004
L7	19	7.32	1910	1356	635	184	126	365	295	47	125	0.34	0.081	0.0005	0.001
L8	18	7.4	1530	1345	620	162	192	355	210	52	95	0.7	0.004	0.001	0.005
L9	19	7.21	1864	1270	472	131	48	320	305	47	108	0.82	0.014	0.002	0.0001
L10	22	7.56	2710	2190	927	222	126	435	345	50	270	2.8	0.035	0.007	0.007
Mean	20.77	7.45	2473.2	1847.6	849.5	208.7	122.1	361.1	459.8	57.1	164.1	1.53	0.048	0.003	0.0028
Min.	18	7.21	1530	1270	472	131	48	307	210	40	95	0.34	0.004	0.0001	0.0001
Max.	23.2	7.61	3830	2581	1360	315	192	435	836	83	270	2.9	0.13	0.009	0.007
SD	1.78	0.14	698.17	470.22	263.52	51.57	36.37	43.66	215.42	13.42	57.87	1.0	0.04	0.003	0.003

*Except Temp (^0C), pH and EC in (is/cm) remaining all Parameters are in mg/L.

Table 3: Correlation Coefficients among Various water quality Parameters June 2016.

	Temp	pH	EC	TDS	TH	Ca	Mg	TA	Cl	NO_3	SO_4	F	Cr	As	Pb
Temp	1														
pH	-0.327	1													
EC	-0.072	0.339	1												
TDS	-0.065	0.311	0.995	1											
TH	0.105	0.230	0.955	0.958	1										
Ca	0.027	0.565	0.880	0.866	0.866	1									
Mg	0.222	0.131	0.871	0.887	0.951	0.774	1								
TA	-0.137	0.406	0.859	0.853	0.784	0.745	0.767	1							
Cl	-0.275	0.513	0.925	0.924	0.814	0.815	0.701	0.797	1						
NO_3	0.044	0.5611	0.865	0.839	0.878	0.882	0.782	0.763	0.808	1					
SO_4	0.050	0.329	0.944	0.939	0.967	0.909	0.939	0.867	0.814	0.893	1				
F	-0.165	0.408	0.838	0.833	0.765	0.769	0.749	0.982	0.751	0.713	0.860	1			
Cr	-0.003	0.154	0.473	0.496	0.562	0.613	0.664	0.532	0.345	0.401	0.679	0.616	1		
As	-0.194	0.637	0.636	0.613	0.581	0.842	0.480	0.697	0.654	0.707	0.723	0.735	0.654	1	
Pb	0.286	0.191	0.215	0.222	0.217	0.493	0.182	0.30	0.172	0.193	0.316	0.376	0.498	0.664	1

drinking water permissible limit is 500mg/L. The analyzed data shows that all samples in both season had more TDS value permissible limit (Table 1 and 2).

The total hardness is depends on availability of calcium and magnesium ions in water. The maximum value of hardness was observed on L3 site and minimum was on L9 site in both seasons. In ground water total hardness is mainly contributed by calcium, magnesium, carbonate, bicarbonate, Sulphate and chloride of calcium and magnesium salt (Ramesh and Thirumangai, 2014). In present study, all sampling sites, ground water have high hardness value as compared with the standard values 200 mg/L as per IS 10500-2012 and this may be due to industrial effluents discharges and leaches. Calcium is the cation found in ground water which is the complex form of total hardness. It was found from ranges between 177-412 mg/l as well as 131-315 mg/l in June 2016 and January 2017. The permissible limit of drinking water is 75 mg/l so all the sampling sites in industrial area of Jajmau have high calcium concentration and crossed the permissible limits. Calcium and magnesium are most common constituents of natural waters and both are the contributor of total hardness. In ground water, magnesium was also found in higher value having ranges between 49-167 mg/l and 48-192 mg/l in June 2016 as well as January 2017. All the samples exceeded the permissible limits. In ground water, maximum alkalinity was found on L3 in June 2016 and L10 in January 2017. Alkalinity

Table 4: Correlation Coefficients among Various water quality Parameters January 2017.

	Temp	pH	EC	TDS	TH	Ca	Mg	TA	Cl	NO_3	SO_4	F	Cr	As	Pb
	Temp	1													
pH	0.279	1													
EC	0.792	0.175	1												
TDS	0.607	0.425	0.83	1											
TH	0.739	0.287	0.961	0.886	1										
Ca	0.787	0.183	0.946	0.772	0.960	1									
Mg	-0.072	0.211	0.122	0.231	0.346	0.347	1								
TA	0.182	0.292	0.523	0.539	0.544	0.507	0.434	1							
Cl	0.554	0.219	0.902	0.794	0.893	0.809	0.119	0.415	1						
NO_3	0.581	-0.006	0.819	0.679	0.851	0.792	0.323	0.342	0.832	1					
SO_4	0.730	0.293	0.745	0.778	0.726	0.715	0.142	0.671	0.472	0.524	1				
F	0.790	0.200	0.769	0.710	0.749	0.728	0.159	0.522	0.531	0.718	0.917	1			
Cr	0.149	0.325	0.516	0.456	0.516	0.456	0.128	0.562	0.684	0.463	0.276	0.201	1		
As	0.233	0.571	0.475	0.565	0.444	0.346	0.081	0.773	0.465	0.263	0.608	0.523	0.569	1	
Pb	0.201	0.085	0.237	0.374	0.323	0.372	0.513	0.425	-0.028	0.017	0.478	0.331	-0.342	0.126	1

has acid neutralizing ability. The alkalinity of water is due to the salts of carbonates, bicarbonates, borates and silicates along with the hydroxyl ions in the Free State (National Environmental Engineering Research Institute). Alkalinity is correlated with pH. Chloride is also an essential parameter of drinking water. It mainly found in water in form of sodium chloride. Chloride is also found above the prescribed limit. As per IS 10500-2012, Acceptable limit for chloride 250 mg/l. Maximum Chloride is found on L3 site ie 905 mg/l in year June 2016 and 836 mg/l on L1 site in January 2017. High concentration of chloride is due to the invasion of domestic wastes and disposals by human activities (Jha and Verma, 2000). The analyzed chloride value in all samples has been observed to be high, which can cause erosion and setting of iron plates or pipes. Contamination of drinking water/ground water by nitrate is more common due to human exercises. It found in water in dissolve form and can move effectively through soil. The nitrate range lied between 47- 84 mg/l in June 2016 and 40-83 mg/l in January 2017, almost all samples were in above the range of acceptable limit i.e. 45 mg/l except on L6 site in January 2017. Nitrate is form due to different chemical fertilizers, rotten vegetable and animal hide, domestic effluents and sewage sludge disposal to land. Excessive concentration of nitrate in drinking water is unsafe for health. Sulphate is also found in soluble form. In the present study, sulphate ion is estimated to vary from 115-345 mg/L in June 2016 and 95-270 mg/l in January 2017. It is also found in high concentration but in some locations, It found under the acceptable limit *i.e.* 200 mg/l as per standard 10500-2012. The high amount of sulphate causes diarrhea. Hence it is clear that all most samples are free from sulphate problems except few. Fluoride is also important but in excessive amount in water causes the florosis. The fluoride range observed was 0.56 to 3.2 mg/L and 0.34 to 2.9 mg/l in 2016 & 2017. Maximum standard limit of fluoride is 1.0 mg/l. Few samples are found in standard range.

Toxic metals like Chromium, arsenic and lead was also found in ground water. Mainly Chromium was found in higher concentration on most of the locations. The maximum allowable limit for chromium as per IS 10500-2012 guidelines, is 0.05 mg/l. Metals are essential component but can be harmful in higher amount. The Cr is toxic to human even in low concentration. In June 2016, Cr was found between 0.004-0.1 mg/l and in January 2017, Cr was found in the range of 0.004-0.13 mg/l Chromium is found on two forms, hexavalent chromium and trivalent chromium. Hexavalent chromium is the most toxic form of chromium. Chromium is the most worrisome of these: popular in the tanning industry because it makes leather goods (Article on ground water Pollution, 2011). The main source of Chromium in Kanpur industrial area is tanning leather industries. Exposure to chromium is associated with many chronic diseases such as dermatitis, ulcers and perforation of the nasal septum and respiratory illness as well as increased lung and nasal cancer (ATSDR 2008; Pandey *et al.,* 2010). Lead and Arsenic was also found but concentration was below detection limit.

Conclusion

The ground water sample collected from ten different locations of industrial area Jajmau, Kanpur, Uttar Pradesh and analyzed and on the basis of these analysis the following conclusions were arrived. The pH of the entire water samples is well within the permissible limits but all other parameters are found above the acceptable limits. in industrial study area the ground water quality is based on TDS value which is very high and on some sites it was found above the permissible limits. The permissible limits of drinking eater as per IS 10500-2012 is 2000 mg/l. The effect of treated effluent with high TDS affecting the ground water quality in surrounding villages. The waste water from industries discharged with different types of pollutants is causing serious health problems in industrial area of Kanpur City due to improper treatment plants. The water of the River Ganga is also contaminating by toxic metals. These toxic pollutants affect the surface water as well as sub surface water and making it unsuitable for drinking and irrigation purposes due to leaching. The situation is alarming and must be remedied by putting restrictions on the industries and requiring them to treat their wastewater before discharge. The sampling stations which are near to effluent channel is highly polluted and toxic in nature due to presence of chromium concentration. Hardness, chloride sulphate nitrate and alkalinity were also found on almost sites beyond the acceptable limits. L1, L3 and L10 were highly affected sites. Based on the correlation study, it can be concluded that all the parameters are more or less correlated with each other.

Overall the Ground water of industrial area is not safe for drinking purposes. It is clear that the ground water of Jajmau is highly contaminated due to tanning activity. In area heavy metals and other parameters are found beyond the acceptable limits as per IS 10500:2012. So the ground water in the studied area is not fit for drinking purpose before proper treatment and heavy metals consumption in drinking water causing serious public health hazard.

References

Agrawal, Nivedita, R. Singh and P.M. Chaubey (2016). Assessment of Ground Water Toxicity Due to Tannery Industry at Jajmau, Kanpur (UP), International. *Journal of Innovative Research in Science, Engineering and Technology*, **5(3)**.

Alper, Baba and T. Gokmen (2011). Groundwater contamination and its effect on health in Turkey, *Environmental Monitoring and Assessment,* **183(1-4):** 77-94.

APHA Standard methods for examination of water and waste water, 20th edn, (Washington),145, 1998.

Article On ground water Pollution, Kanpur (2011).

ATSDR, "Toxicological profile for chromium (2008). US Department of Health and Human Service". Public Health Service. 61-513.

Barman, S.C., R.K. Sahu, S.K. Bhargava and C. Chaterjee (2000). Distribution of heavy metals in wheat, mustard and weed grown in field irrigated with industrials, *Bull. Environ. Contamnation Toxicol*, **64:** 489-496.

Barnhart, J. (1997). Occurrence, uses and properties of chromium, Regul. *Toxicol. Pharmacol*, **26:** 53-57.

Beg, K. R. and S. Ali (2008). Chemical Contaminants and toxicity of Ganga river sediment from up and down stream area at Kanpur Am. *J. Environ. Sci.*, **4(4):** 362-366.

Bhatt, L.R., P. Lacoul, H.D. Lekhak, P.K. Jha (1999). *Pollution Research*, **18(14):** 353-358.

Bhattacharya, T., S. Chakraborty and N. Tuck (2012). Physico-chemical Characterization of ground water of Anand district, Gujarat, India, *I. Res. J. Environment Sci.,* **1(1):** 28-33.

Central Leather Research Institute report on capacity utilization and scope for modernization in Indian tanning Industry (1990). CLRI Chennai, P. 12.

Chandra, Mohan K., J. Suresh and P. Venkteswarlu (2014). Physico-chemical analysis of bore- well water of Karnool environs, Andra Pradesh. *Journal of chemical and Phrmaceutical Research*, **6(9):** 77- 80.

Chilton, J. (1996). Water Quality Assessments - A Guide to Use of Biota, Sediments and Water in Environmental Monitoring - Second Edition Edited by Deborah Chapman © 1992, UNESCO/WHO/UNEP ISBN 0 419 21590 5 (HB) 0 419 21600 6 (PB).

Efe, S.I., F.E. Ogban, M.J. Horsfall and E.E. Akparhonor (2005). Seasonal variation of physicochemical characteristics in water resources quality in western Niger Delta Region Nigeria. *Journal Application Environmental Mgt*., **9(1):** 191-195.

Gowd Srinivasa, S., M. Ramakrishna Reddy and P.K. Govil (2010). Assessment of heavy metal contamination in soils at Jajmau (Kanpur) and Unnao industrial areas of the Ganga Plain, Uttar Pradesh, India, 15, **174(1-3):**113-21.

Harilal, C.C., A. Hashim, P.R. Arun and S. Baji (2004). *Journal of Ecology Environ. Conservation*, **10(2):** 187-192.

Heikka, R.A. (2007), Multivariate monitoring of water quality: A case study of Lake Simple, *Finland. J. Chemomet*., **22:** 747-751.

Heydari, M.M., A. Abasi (2013). Correlation Study and Regression Analysis of Drinking Water Quality in Kashan City, Iran Seyed Mohammad Rohani and Seyed Mohammad Ali Hosseini Middle-East, 2013. *J. Sci. Res.,* **13 (9):** 1238-1244.

Jha, A.N. and P.K. Verma (2000). Physico-chemical properties of drinking water in town area of Godda district under Santal Pargana (Bihar), India, *Poll. Res.,* **19(2):** 75–85.

Karunakaran, K., P. Thamilarasu and R. Sharmila (2009). Statistical study on physicochemical characterstics of ground water in and around namakkal, Tamilnadu, India, *E- Journal of chemistry*, **6(3):** 909-914.

Jinwal, A. and S. Dixit (2008). Pre and Post monsoon variation in physico-chemical characteristics in groundwater quality in Bhopal, India. *Asian J. Exp. Sci*., **22(3)**: Mahananda.

Joarder, M. A. M., F. Raihan, J.B. Alam and S. Hasanuzzaman (2008). *Int. J. Environ. Res.*, **2(3):** 291.

Khan, A.S. and P. Shivastava (2012). Physicochemical characteristics of ground water in around Allahabad City: A Statistical Approach, Bulletin of environmental and *Scientific research*, ISSN-2278-5205, **1(2)**: 28-32.

Kotas, Y.P. and Z. Stasicka (2000). Chromium occurrence in the environment and methods of its speciation, *Environ. pollut.*, **107:** 263-283.

Mehta, K.V. (2010). Physicochemical characteristics and statistical study of groundwater of some places of Vadgam taluka in Banaskantha district of Gujarat state (India). *Journal of Chemical Pharmaceutical Research*, **2(4):** 663670.

Miao, Y., C. Fan and J. Guo (2012). China's water environmental problems and improvement measures. *Resource. Econ. Environ.*, Prot. 3, 43e44.

Mondal, N.C., V.K. Saxena and V.S. Singh (2005). Impact of pollution due to tanneries on ground water regime, *Current science*, **88(12)**.

Murhekar, G.K.H. (2011). Assessment of physicochemical status of ground water samples in Akot city. *Res.J. Chem. Sci*., **(4):** 117-124.

National Environmental Engineering Research Institute.

Pandey, V.C., J.S. Singh, A. Kumar and D.D Tewari (2010). Accumulation of Heavy Metals by Chickpea Grown in Fly Ash Treated Soil: *Effect on Antioxidants". Clean – Soil, Air, Water*, **38(12)**, p.1116 –1123.

Pawari, M.J. and S. Pawande (2015). Ground Water Pollution & Its Consequences. *International Journal of Engineering Research and General Science*, **3(4)**: ISSN 2091-2730.

Raju, N.J., P. Ram and S. Dey (2009). Groundwater Quality in the Lower Varuna River Basin, Varanasi District, Uttar Pradesh. *Journal of the Geological Society of India,* **73(2):** 178-192.

Ramesh, K. and V. Thirumangai (2014). Impact of tanneries on quality of ground water in Pallavaram Chennai Metropolitan City. *Journal of engineering Research and Application*. ISSN:2248-9622, **4(1Version 3)**: 63-70.

Ravenscroft, P. (2003). Overview of hydrogeology of Bangladesh. Chapter 3, In: Rahman AA, Ravenscroft P. editors. Ground water resources and development in Bangladesh, Dhaka: The university press Ltd; 466 pp.

Shyamala, R., M. Shanthi and P. Lalitha (2008). Physicochemical analysis of borewell water samples of Telungupalayam area in Coimbatore District, Tamilnadu, India, *E-Journal of chemistry*, **5(4):** 924-929.

Sinha, S., A.K. Gupta, K. Bhatt, K. Pandey, U.N. Rai and K.P. Singh (2006). Distribution of Metals in the Edible Plants Grown at Jajmau, Kanpur (India) Receiving Treated Tannery Wastewater: *Relation with Physico-Chemical Properties of the Soil*, **115:** 1-22.

Sonawane, V.Y. and A.M. Khole (2010). Water quality of some drinking waters in Parbhani city: a case study. *Journal of Chemical Pharmaceutical Research*, **2(5):** 104107.

Sudhakar, G., G. Swarnalatha, Z. Vishnuvardhan and D. Harika (2010). Statistical Analysis of the Groundwater Samples from Bapatla Mandal, Guntur District, Andhra Pradesh, India, IOSR. *Journal Of Environmental Science, Toxicology And Food Technology*,**8(1)**: 27-32.

Tao, T. and K.L. Xin (2014). Public health: a sustainable plan for China's drinking water. Nature 511, 527e528.