GLOBAL INSTITUTE OF PHARMACEUTICAL EDUCATION & RESEARCH (GIPER)

CONDUCTING BACHELOR IN PHARMACY (B. PHARM) & MASTER IN PHARMACY (M. PHARM)
Approved by AICTE & PCI, New Delhi. Affiliated to Uttarakhand Technical University, Dehradun

Ref. No. GIPER/B. PHARM/2018/424 Date 30/09/18

To

Dr. Arun Kumar,
Professor and MNRE Chair Professor
Alternate Hydro Energy Centre
Indian Institute of Technology Roorkee
Roorkee-247667, Uttarakhand

Sub: Submission of work done till date regarding project proposal under Water for Welfare: an Uttarakhand initiative

Dear Sir,

I am enclosing the report research work done till date regarding project proposal entitled **"Study of ground water quality of Kashipur industrial area"** for your kind consideration.

The present report contains study of ground water quality of Kashipur industrial area in which three phases (summer season, rainy season and post monsoon) of samples were being collected and tested as per the protocols. Computational analyses of physicochemical parameters related to the quality of groundwater is also done.

I would like to apply for future extension of this project work regarding microbiological testing of drinking water in Kashipur areas. Please allow for the same and sanction the grant accordingly. I am ready for the presentation and interaction with your experts regarding this if you give me an opportunity.

The total expenditure till date is more than the amount received by us. Therefore, once again I request you to please transfer the remaining sanctioned fund to the Institute account. Enclosed find please publications in international journals and conference presentation.

Thanking you,

Sincerely,

(Dr. Sisir Nandi)
Principal Investigator

Professor & H.O.D.
Dept. of Pharmaceutical Chemistry
Global Institute of Pharmaceutical
Education and Research
Kashipur-244713, Uttarakhand

Forwarded

DIRECTOR
Global Institute of Pharmaceutical
Education & Research (GIPER)
Jaspur Road, Kashipur

E-Mail: sisir.iicb@gmail.com
Mobile: +91 7500458478

Enclo: 1. Research work report; 2. List of publications; 3. Conference presentation

Report of research work already done for the project proposal entitled "Study of ground water quality of Kashipur industrial area"

Funded by

Water for Welfare: An Uttarakhand Initiative" (WFW-UI) a Virtual Centre of Excellence, having its secretariat at IIT Roorkee established vide Government of Uttarakhand

Principal Investigator (PI):

Name: Dr. Sisir Nandi,

Designation: Professor and HOD, Dept of Pharmaceutical Chemistry,
Global Institute of Pharmaceutical Education and Research (GIPER), Kashipur-244713, District: U.S.Nagar, Uttarakhand, India

Telephone No. +917500458478; **E-mail:** E-mail: sisir.iicb@gmail.com;

Co-PI: Mr. Sarfaraz Ahmed,
Designation: Asst. Professor, Global Institute of Pharmaceutical Education and Research (GIPER), Kashipur-244713, District: U.S.Nagar, Uttarakhand, India

(I) Experimental work done

Kashipur is an industrial belt with many sectors. The Government of Uttarakhand, since its inception, has taken several initiatives for development of the State. One of them is water for Welfare. To protect ground water and to prevent the ground water pollution of Kashipur area, an attempt has been made in the present study to test the physicochemical parameters including total hardness, alkalinity, chloride, fluoride, sulphate, iron, zinc, copper and heavy metal atoms such as lead, arsenic etc. Imbalance of these parameters may degrade the quality of ground water and it may produce negative impact on the health and society in context with drinking, agriculture and industrial purposes. Therefore, degradation of ground water is a big issue in lieu of natural ecological imbalance.

Kashipur city is situated in the Udham Singh Nagar district of Uttarakhand in India. It is famous for the pharmaceutical and paper mill industries which produce detrimental chemicals. Industrial effluents were being thrown into the ponds and rivers. This may degrade the quality of

groundwater in the vicinity. The deterioration in physicochemical and biological properties of groundwater may hamper the mankind.

Collection groundwater samples

Kashipur industrial belt is surrounded by Agron Remedies Pvt Ltd Moradabad Road, India Glycols Ltd Bazpur road, The Bazpur Coop. Sugar Factory Ltd. Distillery Unit, Bazpur, M/s Sidharth Paper Ltd 7th Km Moradabad road, Shree Shayam Pulp & Board Mills Ltd. UnitII, Moradabad Road, M/s Siddheshwari Paper Udyog Ltd 7th Km Moradabad road, Prolific papers (P) Ltd. 5th Km stone, Aliganj Road, Kashipur, Devrishi paper Pvt. Ltd. , Jaspur Road, Jagatpur Patti, Jaspur, Vivimed Lab Ltd Kundeshwari.

Water samples from hand pumps and submersible wells were collected from different surrounding industrial places in summer (in the mid of May, 2018), monsoon (mid of August, 2018) and post-monsoon (3rd week of September, 2018) time. The samples were collected in pre cleaned laboratory borosilicate reagent bottles and capped with the stopper. The room temperature was maintained with necessary precautions. The samples were being tested to compute the physicochemical parameters within two days from the date of collection of the water utilizing standard methodologies.

Standard methods as per Indian Pharmacopoiea 2016 were followed for the estimation of total hardness, total alkalinity, chloride, sulphates, iron, heavy metal atoms such as lead, arsenic etc., fluoride, and copper. Normal limit of these elements are given as 175-358 ppm, 231.8-542.8 ppm, 50-350 ppm, 200-250 ppm, 0.18-1.59 ppm, 0.02-0.08 ppm, 0.010 ppm, 0.7-1.9 ppm and 0.017-0.061 ppm respectively.

Methods of testing of the water samples

Calculation of total hardness

The hardness of water is a measure of the total concentration of the bicarbonate, chloride, and sulfates of calcium and magnesium. Water hardness is due to the presence of multivalent metal ions which come from minerals dissolved in the water. Hardness is judged on the ability of these ions to react with soap to form a precipitate or soap scum. So far as reported, hard water is not harmful to the health and soft water causes cardiac problem. Total hardness of the water samples

were calculated using volumetric titration method which considers Eriochrome Black T (EBT) as an indicator and EDTA as titrant. The test is carried out in accordance to IS: 3025 (Part 21) – Reaffirmed 2002.

Calculation of total alkalinity

Total alkalinity in water is due to hydroxyl, carbonate and bicarbonate ions. Large amount of alkalinity imparts bitter in test. The alkalinity of water can be determined by titrating the water sample with sulphuric acid of known values of pH, volume and concentration. Based on stoichiometry of the reaction and number of moles of sulphuric acid needed to reach the end point, the concentration of alkalinity in water is calculated. Phenolphtalein, methyl red and bromocresol green are used as mixed indicator in the present experiment. The test is given in IS: 3025 (Part 23) – Reaffirmed 2003.

Qualitative estimation of chloride, sulphates, iron, heavy metal atoms such as lead and arsenic

Limit test was carried out for the qualitative detection of impurities and to control small quantities of impurity which is likely to be present in the water samples. Even, the presence of very minute quantity of the impurity may produce cumulative toxicity and harmful for the health. So, limit test is nothing but to identify the impurities present in the substance and compare it with standard and decide whether the sample contains the amount of impurities above the limit or within the limit. In the present study, limit tests for the qualitative estimation of chloride, sulphates, iron, heavy metal atoms such as lead and arsenic were being carried out by the standard methodologies as prescribed in Indian pharmacopoeia 2016.

Limit test of chloride is based on the reaction of soluble chloride with silver nitrate in presence of dilute nitric acid to form silver chloride, which appears as solid particles (Opalescence) in the solution. Limit test of sulphate is based on the reaction of soluble sulphate with barium chloride in presence of dilute hydrochloric acid to form barium sulphate which appears as solid particles (turbidity) in the solution. Limit test of Iron is based on the reaction of iron in ammonical solution with thioglycollic acid in presence of citric acid to form iron thioglycolate which is pale pink to deep reddish purple in color. Heavy metals such as lead and arsenic produce cumulative toxicity which hampers nervous system in the baby. Presence of heavy metals in above the limit

in food and drinking water is very dangerous for the health. The limit test for lead is based on the reaction between the solution of lead and a saturated solution of hydrogen sulphide. In acidic media, it produces reddish/ black color with hydrogen sulphide which is compared with standard lead nitrate solution. Limit test of Arsenic is based on the reaction of arsenic gas with hydrogen ion to form yellow stain on mercuric chloride paper in presence of reducing agents like potassium iodide. It is also called as Gutzeit test and requires special apparatus. Arsenic, present as arsenic acid in the sample is reduced to arsenious acid by reducing agents like potassium iodide, stannous acid, zinc, hydrochloric acid, etc. Arsenious acid is further reduced to arsine (gas) by hydrogen and reacts with mercuric chloride paper to give a yellow stain.

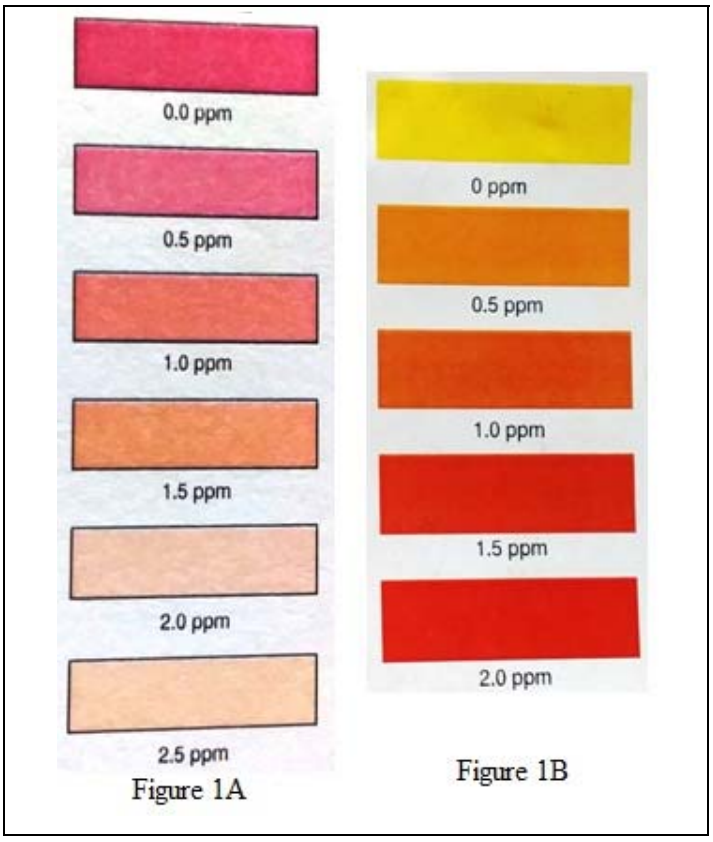
Test for fluoride

Fluoride is frequently encountered in minerals and in geochemical deposits and is generally released into subsoil water sources by slow natural degradation of fluorine contained in rocks. A higher concentration of fluoride causes serious health hazards such as dental, skeletal and non-skeletal fluorosis. Potable water can be checked to control fluoride level in water. In the present study, Aqua check fluoride testing kit WT012 has been used for the determination of fluoride content present in the water samples. Aqua check fluoride testing kit WT012 contains two reagents such as 012A and 012B respectively. 10 ml of the water sample was taken in a test tube jar. 3 drops of reagent 012A and 8 drops of reagent 012B were being added simultaneously and mixed well using a glass rod and then allowed the test tube for 4-5 minutes. Level of the fluoride content was noted from the provided chart by making comparison with the standard color (Figure 1A) and the color developed in the test tube.

Test for copper

Copper is a reddish metal that occurs naturally in rock, soil, water, sediment, and air. It has many practical uses in our society and is commonly found in coins, electrical wiring, and pipes. It is an essential element for living organisms, including humans, and-in small amounts-necessary in our diet to ensure good health. However, too much copper can cause adverse health effects, including vomiting, diarrhea, stomach cramps, and nausea. It has also been associated with liver damage and kidney disease. In the present study, copper testing kit WT046 containing 046A and 046 B reagents are used to check the level of copper in groundwater samples. In the method, 10

ml of the water sample was taken in a test tube jar. 2 drops of reagent 046A and 1 drop of reagent 046B were being added simultaneously and mixed well using a glass rod and then allowed the test tube for 5-10 minutes. Level of the copper content was checked from the provided chart by making comparison with the standard color (Figure 1B) and the color developed in the test tube.



Figures 1A-B: Standard fluoride color chart (1A) and standard copper color chart (1B)

Measurement of the pH

pH of the samples were being measured using pH meter which determines the hydrogen-ion activity in water-based solutions, indicating its acidity or alkalinity expressed as pH. The pH meter measures the difference in electrical potential between a pH electrode and a reference electrode. The difference in electrical potential relates to the acidity or pH of the solution.

Results and Discussion

In the mid of May, 2018, 1st phase groundwater samples were collected from submersible pumps of the different locality of Sugar Mills (S1), Pashupati Polytex (S2), Agron Remedies Pvt. Ltd and Anaj Mandi (S3), Kunda Chowraha (S4), India Glycol Limited (S5), Maldhan residential area (S6), Government hospital Kashipur (S7), Vivimed Lab Ltd Kundeshwari (S8) and *Surya* Roshni Limited, Moradabad road (S9). These samples were subjected for the testing of pH, total hardness, alkalinity, limit test for chloride, sulfate, iron, lead and arsenic and test for fluoride and copper. Samples were tested as per the standard methods. Contribution of different physicochemical parameters is represented by indicator variables, which occupy the value of 1 or 0 if corresponding parameter is within or above the limit and results, were summarized in the Table 1 and Table 2 denotes the parameter value as obtained from the corresponding test.

Table 1: Calculated physicochemical parameter data of groundwater of different Kashipur industrial zone (summer)

Sl. No	Total hardness	Total alkalinity	Limit test							pH
			Chloride	Sulphate	**Iron**	**Lead**	**Arsenic**	Fluoride	Copper	
S1	1	1	1	0	**1**	**1**	**1**	1	0	7.65
S2	1	1	1	0	**1**	**1**	**1**	1	1	7.62
S3	1	0	0	0	**1**	**1**	**1**	0	1	7.58
S4	0	1	1	0	**1**	**1**	**1**	1	1	7.80
S5	1	0	1	0	**1**	**1**	**1**	1	0	7.76
S6	1	1	1	1	**1**	**1**	**1**	1	1	7.40
S7	1	1	0	0	**1**	**1**	**1**	1	0	7.30
S8	1	1	1	1	**1**	**1**	**1**	0	1	7.50
S9	1	1	1	1	**1**	**1**	**1**	1	1	7.61

1= acceptable (within the limit); 0 = not acceptable (above the limit)

Table 2: Physicochemical parameter values (ppm) of total hardness, alkalinity, fluoride and copper (Summer)

Sl. No	Total hardness	Total alkalinity	Flouride	Copper
S1	210	258	0.50	0.50
S2	240	320	0.50	0.00
S3	200	221	0.00	0.00
S4	150	333	1.00	0.00
S5	195	216	0.50	0.50
S6	205	249	0.50	0.00
S7	305	307	0.50	1.50
S8	225	250	0.00	0.00
S9	225	255	0.50	0.00

Physiochemical data of water samples of summer season reveals that iron, lead and arsenic content in all the water samples are within the limit as highlighted in the above Table 1 while sulphate, chloride, fluoride and copper level are above the limit in some localities. Sulphate level of most of the water samples except S6, S8 and S9 are above the limit. Amount of the Chloride ions for samples S3 and S7 do not pass. Total hardness for sample S4 is below the limit whereas total alkalinity content for samples S3 and S5 are below the limit. Fluoride test shows that the presence of fluoride ions in S1-S2, S4-S7 and S9 are within the limit and sample S3 and S8 contain fluoride amount below the limit. The samples S1, S5 and S7 contain copper ion an amount of 0.5 ppm, 0.5 ppm and 1.5 ppm which are not within the permeable limit. Alkalinity and hardness level was quite normal in mostly water samples. pH of all the water samples is slightly basic.

2nd phase water samples were collected in the mid of August 2018 from different Kashipur localities including Sugar Mill (S10), Pashupati Polytex (S11), Agron Remedies Pvt Ltd and Anaj Mandi (S12), Kunda Chowraha (S13), India Glycol Limited (S14), Shakti Chowraha, Mahuakheraganj (S15), Government hospital Kashipur (S16), Vivi med Lab Kundeswari (S17), *Surya* Roshni Limited, Moradabad road (S18), Genesis Mahuakheraganj (19), Devrishi paper mill (S20), Sugar Mill Nadahi (S21), Government hospital Jaspur (S22), IIM kashipur (S23), Techno Electric, Moradabad road (S24) and GIPER Jaspur road (S25). Samples were tested and physicochemical parameters with or without acceptable were denoted by 1 and 0 digit which were tabulated in Table 3. Physicochemical parameter values of total hardness, alkalinity, fluoride and copper (Rainy season) were calculated and given in Table 4.

Table 3: Calculated physicochemical parameter data (Rainy season) of groundwater of different Kashipur industrial zone

Sl. No	Total hardness	Total alkalinity	Limit test							pH
			Chloride	Sulfate	Iron	Lead	Arsenic	Fluoride	Copper	
S10	0	0	**1**	1	**1**	**1**	**1**	1	0	7.14
S11	1	0	**1**	0	**1**	**1**	**1**	1	1	7.23
S12	1	0	**1**	1	**1**	**1**	**1**	1	1	6.94
S13	1	0	**1**	0	**1**	**1**	**1**	1	1	7.65
S14	1	1	**1**	1	**1**	**1**	**1**	1	1	7.45
S15	1	0	**1**	1	**1**	**1**	**1**	1	1	7.25
S16	1	1	**1**	0	**1**	**1**	**1**	1	1	7.13
S17	0	0	**1**	0	**1**	**1**	**1**	1	1	6.89

S18	1	0	**1**	0	**1**	**1**	**1**	1	1	7.25
S19	0	0	**1**	0	**1**	**1**	**1**	1	1	6.71
S20	1	0	**1**	0	**1**	**1**	**1**	1	1	7.28
S21	0	1	**1**	0	**1**	**1**	**1**	1	1	6.95
S22	0	0	**1**	0	**1**	**1**	**1**	1	0	7.05
S23	0	0	**1**	0	**1**	**1**	**1**	0	1	7.16
S24	1	0	**1**	0	**1**	**1**	**1**	1	1	7.33
S25	1	0	**1**	1	**1**	**1**	**1**	1	1	7.10

1= acceptable (within the limit); 0 = not acceptable (above the limit)

Table 4: Physicochemical parameter values (ppm) of total hardness, alkalinity, fluoride and copper (Rainy season)

Sl. No	Total hardness	Total alkalinity	Fluoride	Copper
S10	370	170	0.50	0.5
S11	290	139	0.50	0.00
S12	315	200	1.00	0.00
S13	195	131	1.00	0.00
S14	240	350	1.00	0.00
S15	325	225	0.50	0.00
S16	280	216	0.50	0.00
S17	495	214	0.50	0.00
S18	240	194	0.50	0.00
S19	425	221	0.50	0.00
S20	270	210	0.50	0.00
S21	450	248	0.50	0.00
S22	480	175	0.50	0.5
S23	500	221	0.00	0.00
S24	265	175	1.00	0.00
S25	310	172	0.50	0.00

It was shown that total hardness data of S10, S17, S19 and S21-S23 are 370 ppm, 495 ppm, 425 ppm, 425 ppm, 480 ppm and 500 ppm. These are not acceptable because of above the normal limit. Total alkalinity of almost water samples decreases from the normal level. Chloride, iron, lead and arsenic levels were shown within the permeable limit for all the water samples. Fluoride and copper content of mostly water samples are within the limit while sulfate level is above the limit in mostl samples. pH of some samples becomes acidic during rainy season.

3rd phase water samples were collected in the post monsoon of 3rd week of September 2018 from M/s Sidharth Paper Ltd 7th Km Moradabad road (S26), Prolific papers (P) Ltd. 5th Km stone,

Aliganj Road (S27), Vishvakarma Paper and Board Limited, 4.5 Km. Ramnagar Road (S28), Cheena Papers Limited, 9th Km. stone, Bazpur (28), Nainy paper Ltd, 7 km, Moradabad road (S29), Sugar Mills Kashipur (S30), Shree Shayam Pulp and Board Mills Ltd. Unit II, Moradabad road, Kashipur (S31), Flexituff International Limited, Mahuakheraganj (S32), Konark Industries, Mahuakheraganj (S33), Videocon Moradabad road (S34), India Glycol Limited (S35), Agron Remedies Pvt Ltd (S36), Government hospital Kashipur (S37), Vivi med Lab Kundeswari (S38), *Surya* Roshni Limited, Moradabad road (S39) and Genesis Mahuakheraganj (S40). Samples were tested and physicochemical parameters with or without acceptable limit were denoted by 1 and 0 digit (Table 5). Physicochemical parameter values of total hardness, alkalinity, fluoride and copper (post monsoon) were calculated and given in Table 6.

Table 5: Calculated physicochemical parameter data (post monsoon) of groundwater of different Kashipur industrial zone

Sl. No	Total hardness	Total alkalinity	Limit test							pH
			Chloride	Sulfate	**Iron**	**Lead**	**Arsenic**	**Fluoride**	Copper	
S26	1	1	**1**	1	**1**	**1**	**1**	**1**	1	7.34
S27	1	1	**1**	0	**1**	**1**	**1**	**1**	1	7.20
S28	1	1	**1**	1	**1**	**1**	**1**	**1**	1	7.4
S29	1	0	**1**	0	**1**	**1**	**1**	**1**	1	7.33
S30	1	1	**1**	1	**1**	**1**	**1**	**1**	1	7.35
S31	1	0	**1**	1	**1**	**1**	**1**	**1**	1	7.39
S32	1	1	**1**	0	**1**	**1**	**1**	**1**	1	7.13
S33	1	0	**1**	0	**1**	**1**	**1**	**1**	0	6.89
S34	1	0	**1**	0	**1**	**1**	**1**	**1**	1	7.25
S35	0	1	**1**	0	**1**	**1**	**1**	**1**	1	6.80
S36	1	0	**1**	0	**1**	**1**	**1**	**1**	1	7.20
S37	0	1	**1**	0	**1**	**1**	**1**	**1**	1	7.02
S38	0	0	**1**	0	**1**	**1**	**1**	**1**	1	7.15
S39	1	1	**1**	0	**1**	**1**	**1**	**1**	1	7.26
S40	1	0	**1**	0	**1**	**1**	**1**	**1**	1	7.32

1= acceptable (within the limit); 0 = not acceptable (above the limit)

Table 6: Physicochemical parameter values (ppm) of total hardness, alkalinity, fluoride and copper (post monsoon)

Sl. No	Total hardness	Total alkalinity	Fluoride	Copper
S26	355	235	0.50	0.00
S27	295	240	0.50	0.00
S28	325	232	1.00	0.00
S29	200	140	1.00	0.00

S30	245	345	1.00	0.00
S31	320	230	0.50	0.00
S32	285	238	0.50	0.00
S33	355	225	0.50	0.50
S34	245	195	0.50	0.00
S35	430	238	0.50	0.00
S36	275	220	0.50	0.00
S37	455	245	0.50	0.00
S38	485	195	0.50	0.00
S39	350	235	0.50	0.00
S40	275	200	1.00	0.00

3rd phase test results show that total hardness of the water samples such as S35, S37 and S38 has exceeded the limit. Total alkalinity maintain below the limit for the almost 50% of the sample tested. The level of chloride, iron lead, arsenic, fluoride and copper are almost acceptable for all the samples. Water samples of S26, S28, S30 and S31 are not within the limit of sulphate content as per the standard limit test.

(II) Theoretical work done

In another effort, physicochemical parameters of ground water like total hardness, pH, biocarbonate, chloride, sulphate, fluoride, chromium, iron and lead were studied theoretically. Water that has high mineral content is known as hard water. Hard water contains bicarbonate, chloride and sulphates of calcium and magnesium. When hard water is treated with soap, it gets precipitated in the form of insoluble salts of calcium and magnesium. Hardness of water is a measure of the total concentration of the calcium and magnesium ions expressed as calcium carbonate. Water hardness is due to the presence of multivalent metal ions which come from minerals dissolved in the water. Hardness is judged on the ability of these ions to react with soap to form a precipitate or soap scum. In fresh water the primary ions are calcium and magnesium; however iron and manganese may also contribute. Carbonate hardness is equal to alkalinity but a non-carbonate fraction may include nitrates and chlorides.

Based on these points, total hardness (T.H.) of water can be quantitatively correlated with some parameters like pH, biocarbonate, chloride, sulphate, fluoride, chromium, iron and lead. In the present study, total hardness (T.H.) and these physicochemical parameters data (Table 7) were collected from the published literature [**Sinha et al., Green Chemistry & Technology Letters, 2016, 2: 110-114**].

Table 7: Physicochemical parameters of ground water of Unnao District of Uttar Pradesh

Sample No.	pH	HCO3- mg/l	Cl- mg/l	SO4 2- mg/l	F mg/l	Chromium mg/l	Iron mg/l	Lead mg/l	T.H. mg/l	-log (T.H.) mg/l
AS1	6.87	542.9	24	29	1.81	0.03	1.03	0.03	295	-2.469
AS2	7.1	542.2	107	70	1.41	0.03	0.48	0.02	190	-2.278
AS3	6.7	475.8	127	147	1.03	0.08	0.3	0.03	355	-2.550
AS4	7.2	475.5	77	147	0.46	0.04	0.37	0.05	355	-2.550
AS5	6.9	396.5	121	129	0.36	0.05	0.49	0.04	198	-2.296
AS6	7.3	475.2	184	20	1.03	0.07	0.62	0.05	247	-2.392
AS7	7.4	396.8	57	132	0.39	0.04	0.85	0.02	263	-2.419
AS8	6.8	231.8	96	98	2.03	0.09	1.05	0.01	339	-2.530
AS9	6.6	317.2	162	158	1.36	0.06	0.61	0.03	276	-2.440
AS10	6.8	286.7	205	170	0.62	0.03	0.77	0.04	370	-2.568
AS11	6.8	231.8	210	105	1.31	0.05	0.73	0.01	199	-2.298
AS12	7.2	213.5	198	162	1.61	0.07	1	0.01	305	-2.484

It was well reported that the primary ions responsible for total hardness are bicarbonate, chloride and sulphates of calcium and magnesium. Our aim is to check whether T.H. is dependent on other physicochemical parameters.

In this theoretical study, a quantitative model was developed by correlating negative logarithm of total hardness with the other physicochemical parameters like pH, biocarbonate, chloride, sulphate, fluoride, chromium, iron and lead to check whether T.H. is influenced by any of these physicochemical properties of the ground water.

Minitab software (http://www.minitab.com) was used to develop the model using multiple linear regression (MLR) statistical analyses. In this study, T.H. was taken as dependent variable whereas others are considered as independent variables.

The regression equation is given below.

$$-\log(T.H.) = -1.39 - (0.006)\,PH - (0.00051)\,HCO3^{-} + (0.00011)\,Cl^{-} - (0.0022)\,SO_4^{2-} - (0.090)\,F^{2-} - (1.960)\,Chromium - (0.309)\,Iron - (5.380)\,Lead$$

$N = 12$, $R^2 = 0.724$, $S = 0.105$

Where, N is number of sample observations, R is the square root of multiple R-square for regression, $R^2 = 1 - [\sum (Y_{obs} - Y_{calc})^2 / \sum (Y_{obs} - \bar{Y})^2]$ and S is the standard error of estimation. Y_{obs}, Y_{calc} and $\bar{Y}$ denote observed, calculated and mean of T.H. values, respectively.

Another important statistical metric is the T-value associated with the model, defined as the descriptor coefficient divided by its standard error. Descriptors with large |T| values are important in the predictive model and, as such, can be examined in order to gain some understanding of the nature of property of interest (Table 8).

Table 8: |T|-values of the modeled parameters

Parameters	Coefficient	SE of Coefficient	|T|
PH	-0.0064	0.174	0.04
$HCO3^-$	-0.0005	0.0008	0.58
Cl^-	0.0001	0.0009	0.12
SO_4^{2-}	-.0022	0.0011	2.00
F^{2-}	-0.091	0.129	0.70
Chromium	-1.962	2.192	1.00
Iron	-0.309	0.299	1.03
Lead	-5.376	3.798	1.42

From the above Table 8, it is cleared that T-values of SO_4^{2-}, lead, iron and chromium are higher than other parameters. Therefore, it may be concluded that the total hardness does not only depend on bicarbonate, chloride and sulphates of calcium and magnesium but other significant physicochemical parameters can also govern the total hardness of the ground water such as lead, iron and chromium.

(III) Review work based on pathogenic bacteria present in drinking groundwater

In another attempt, a review based on presence of pathogenic bacteria in drinking water has been published. It may help the general public by creating health awareness and ways to prevent bacterial attack in drinking water. The presence of pathogenic bacteria in drinking water is one of the great issues now-a-days. Dangerous microbial growth causes potential health hazards including intestinal infections, dysentery, hepatitis, typhoid fever, cholera, and other illnesses. The present report summarizes the dangerous effects, common methods of detection, recent outbreaks and possible plan to control the contamination of various common bacteria in drinking water to alert general public to be safe and healthy. Microbiological control of drinking water

should be the norm everywhere. People affected by bacterial diarrheal diseases are those Gram negative bacteria can become dangerous by producing biofilm via quorum sensing mechanisms and cause antibiotic resistant. Therefore, public must be aware of safe drinking water which is free from the dangerous bacterial infection. On application of pressure standing, solar disinfection, reverse osmosis, filtration, chemical oxidation through chlorination of the ground water can produce portable for the drinking to minimize bacterial infections. In this article it ws reported that water should be boiled and cooled at a normal temperature and filtered through cloth or clay vessels. Further, chlorine, $KMnO_4$ and alum can be added as antiseptic to prevent bacterial infection in reserved water.

(IV) Outcome of the research carried out

1. Three phases of groundwater samples of different localities of Kashipur industrial areas were being collected and subjected for the testing of physicochemical parameters governing the quality of the groundwater. Physiochemical data of summer, rainy season and post monsoon were compared. It was found that the alkalinity of water samples decreases during the rainy season and post monsoon period therefore the pH of some samples was changed to slightly acidic. Iron, fluoride, chloride and copper level are becomes normal in mostly water samples during rainy season and post monsoon. Rainy seasons' and post monsoon' data shows that total hardness data become higher than the summer season. This is not harmful for the health. The most important prediction in this study is that heavy metals like lead and arsenic were being within the limit in Kashipur industrial areas. It was also observed that the quality of groundwater during rainy and post monsoon seasons are comparatively better than the summer because rainwater penetrate through many layers of the underground soil which may act as natural filters to retain the impurities and groundwater aquifers move up to saturate the uppermost stratum.

2. In this theoretical study, a quantitative regression model was developed by correlating negative logarithm of total hardness with the other physicochemical parameters like pH, bicarbonate, chloride, sulfate, fluoride, chromium, iron and lead to check whether T.H. is influenced by any of these physicochemical properties of the groundwater. From the study, it is cleared that T-values of Cl^- , SO_4^{2-}, lead, iron and chromium are higher than other parameters. Therefore, it may be concluded that the total hardness does depend not only on chloride and sulfates of calcium and magnesium but also other significant physicochemical parameters such

as lead, iron and chromium that may govern the total hardness of the groundwater. Further, it was experimentally validated by obtaining flocculation produced by the solutions of ferrous sulphate, lead acetate and chromium sulphate on addition of aqueous soap solution.

3. Microbiological control of drinking water should be the norm everywhere. People affected by bacterial diarrheal diseases are those with the lowest financial resources and poorest hygienic facilities. Gram negative bacteria can become dangerous by producing biofilm via quorum sensing mechanisms and cause antibiotic resistant. Therefore, public must aware to be safe in drinking water and free from the dangerous bacterial attack.

(V) Future plan of Research to be carried out

1. Presence of dangerous common bacteria like total coliforms in drinking water will be tested using water testing kits.
2. Computational analyses of the physicochemical parameters data obtained from the above study.

Research article publication based on the project work:

(i) Sisir Nandi*, Sarfaraz Ahmed and Deepak Teotia, To Quest Common Dangerous Bacterial Attack in Drinking Water, J Bioanal Biomed 2018, 10:2; DOI: 10.4172/1948-593X.1000202; **Impact Factor**: 1.14. **DOI**: 10.4172/1948-593X.1000202

(ii) **Sisir Nandi*,** Sharma A, Ahmed S and Teotia D, Quantitative Regression Analysis of Total Hardness Related Physicochemical Parameters of Groundwater, **Pharm Res** 2018, 2(3): 000160. **DOI:** 10.23880/oajpr-16000160

Conference presentation (oral)

Sisir Nandi, QSAR, drug design and ground water quality parameter modeling utilizing pharmacoinformatics, 2nd DST-SERB sponsored national seminar entitled "INNOVATIVE APPROACHES IN PHARMACEU-TICAL DRUG DISCOVERY AND DEVELOPMENT BY USING QSAR METHODS" Nirmala College of Pharmacy, Mangalagiri, Vijaywada, India, 17 March 2018.