Available online at **www.joac.info**

ISSN: 2278-1862

Journal of Applicable Chemistry

2019, 8 (2): 873-883

(International Peer Reviewed Journal)

Drinking Water Monitoring in Catchment Area of River Krishni, Baghpat, Uttar Pradesh, India

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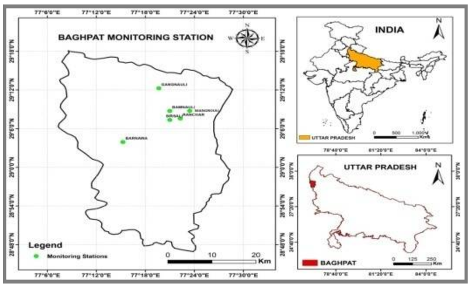
Accepted on 27th February, 2019

ABSTRACT

India has an agriculturally based economy. To address the issues of horticultural land water is as mandatory as air for individual. It could be either surface water from the Rivers or ground water from tube wells. Chemical based agrarian practices are in charge of tainting in groundwater aquifer. Substantial number of industries works as add fuel to fire. The water of Krishni River and its catchment have been contaminated due to the same. Krishni River carries blackish water with an unpleasant odor in non-monsoon seasons as no availability of fresh water. Pre-monsoon sampling from the Krishni River catchment was performed as per APHA standard. 26 water Samples were collected from India Mark-II hand pumps. Physiochemical parameter such as pH, Conductivity, Total alkalinity, Total hardness, TDS, TOC and heavy metals like Fe, Mn, Ni, Mg, Pb, Cd, Al, metalloids like B and non-metal like Se have been analysed and the results were compared with BIS-10500. The value of TDS varies from 230-1372 mg L^{-1} *which is above the Acceptable limit at 6 points. Conductivity in the drinking water sample varies from 487-1792 µmhos* cm^{-1}*. The value of TOC varies from 6.24-19.89* mg L^{-1} *indicate the presence of organic components in drinking water. The concentration of Fe varies from 0.012-5.14 mg* L^{-1} *which indicates that 16 samples have concentration above the acceptable limit. The value of Cd varies from 0.024-0.061 mg* L^{-1} *where the range of Se life from 1.21-1.86 mg* L^{-1}*. All the drinking water samples have the Cd and Se concentration above the permissible limit. Cd is carcinogenic elements and may be responsible for various lives threatening diseases among the villagers* of *Krishni River catchment area.*

Graphical Abstract



Monitoring Stations

Keywords: Krishni River, Hand pumps, TOC, Heavy Metals.

INTRODUCTION

Krishni River is an intermittent in nature, which flow only during monsoons. In the absence of fresh water, River carries mostly industrial and domestic wastewater discharged from nearby town of Saharanpur, Shamli and Baghpat district of Western U.P [1]. It is a tributary of Hindon river and cover 78 Km stretch along side industrial as well as agricultural intensive area. Rapid growth of industrialization and urbanization became an essential part of the modern society but these are responsible for environmental degradation and the quality of surface water is being deteriorated. Ground water aquifers also affected by these trends because of SW-GW interaction [2]. Ground water and surface water are interconnected and recharge each other. As the Ground water table in the vicinity of any surface water stream depletes the surface water stream recharge the ground water aquifer. If the surface water stream has polluted water, the ground water aquifer will be contaminated [3]. In most of the parts of India the availability for drinking water purpose is either ground water or municipal water. As ground water is the main source of water supply for drinking and other purposes in the most areas of India, it must be pollution free otherwise there is a high risk of health for the citizen. The toxic pollutants are entered in the food chain and posing a threat to human health [4]. A number of studies regarding pollution aspects of surface water and its effect on ground water have been carried out by different workers. Ground water samples of Saharanpur district of West U.P seems to be highly polluted due to uncontrolled industrial discharge (Malyan, Kumar and Kumar, 2014). A major portion of pollutants is reported in the Ground water of village ChanednaMaal of Shamli district, due to the pollution in Krishni River because it seems like a drain, filled with blackish water (Dhakyanaika and Kumara, 2010). Umar (2009) also reported high value of heavy metals in the ground water samples of the Yamuna-Krishni sub-basin in Muzaffarnagar District. Another study carried out in Baghpat district by Alam and Umar (2013) reported trace elements in the ground water of Hindon-Yamuna Interfluve region [1, 5-7]. As ground water of Hindon and its tributaries catchment area are reported to be highly polluted and health hazard among the citizen living in the close proximity of these rivers, diagnosed the risk of many life threatening disease like cancer, abdominal disorder and Bone deformity etc. Such types of deadly diseases are reported in the catchment area of Krishni River from the past decades. Hundreds case of cancer have been reported in Gangnauli village alone [8].

MATERIALS AND METHODS

Study area: The study is carried out in Krishni river waterway catchment region of Baghpat district. River get colossal measure of treated and untreated waste from various huge, medium and small-scale Industries, for example sugar, refinery etc. The water level of Krishni River fluctuates from season to season, furthermore relies on upon the industries arranged in its catchment city or town. The shading and smell additionally may differ with season, in monsoon it conveys muddy water however in other season its shading absolutely changes to dark with a terrible smell. Individuals living in the towns or villages of the catchment of Krishni River are constrained to live with such unsuitable smell [9]. Six Villages are chosen for the present study i.e. Gangnauli, Bamnauli, Mangrouli, Ranchar, Barnawa and Sirsali (Figure 1). In these villages Gangnauli, Bamnauli, Ranchar and Barnawa towns are situated at the bank of stream where Sirsali and Mangrouli are situated inside 5 Km range. Latitudes and Longitudes of the selected villages are given in table 1. India Mark-II hand pumps installed by Government of India are chosen for sampling.

Table 1. Latitudes and Longitudes of the sampling villages

S.No	Sampling Village	Latitude	Longitude
1.	Gangnauli	29°12' 15.12"N	77°19' 38.64"E
2.	Bamnauli	29°8' 44.16"N	77°20' 58.92"E
3.	Mangrouli	29°8' 45.978"N	77°23' 25.0404"E
4.	Sirsali	29°7' 21.918"N	77°20' 58.8156"E
5.	Ranchar	29°7' 34.32"N	77°22' 16.32"E
6.	Barnawa	29°3' 55.44"N	77°15' 15.48"E

Krishni River.

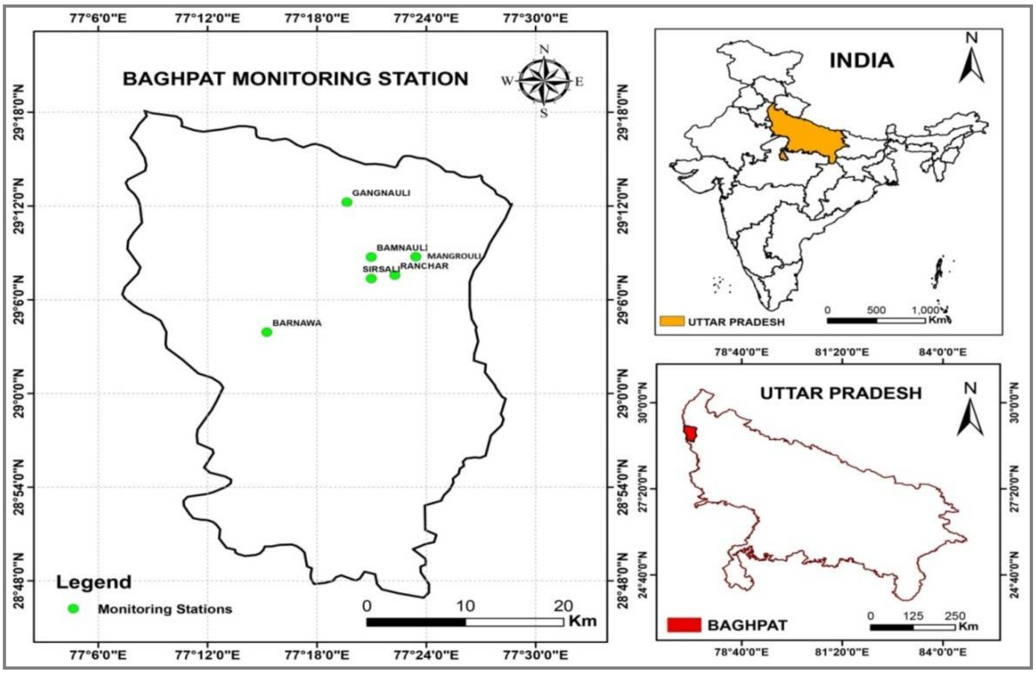


Figure 1. Monitoring Stations.

Sampling and analysis: Before collecting water samples, survey of area was done and found that contaminated water of Krishni River in Baghpat district could be responsible for a number of life-threatening diseases such as cancer, bone deformity and paralysis among residents of several villages along its banks. In a single village named Gangnauli 112 people have died due to cancer in the last two years and 47 are currently battling this disease [8]. On the basis of survey, the Hand pumps were chosen for the analysis. 26 groundwater samples from different location of 6 villages during pre-monsoon (February- March 2015) were collected, by using labelled and pre-treated Teflon bottles. The sample have been collected from the Hand pumps after flushing water for 10 min in order to obtain fresh aquifer water. All the 26 samples were analysed for 19 parameters such as pH, Electrical conductivity, TDS, Total hardness, Alkalinity, ORP, chloride, Mg, Cr, Mn, Fe, Co, Ni, Cu, Zn, Pb, As, Cd, Se etc. using standard procedures recommended by APHA [10]. Parameters like pH was checked onsite. The samples were preserved for heavy metals and other physiochemical analysis. All the collected ground water samples are preserved at 4°C by using thermo-coal box with ice packs and the samples were then transferred to the laboratory for further analysis. For physical parameters like ORP, TDS, Conductivity multi parameter from Orlab-900 and for Alkalinity, Hardness and Chloride content Volumetric analysis were used. ICP-MS was used for the analysis of Heavy metals.

RESULTS AND DISCUSSION

The focused characteristic of ground water of the selected area has been given in table 1. All the groundwater samples were collected from India mark-II hand pumps and the results were compared with BIS-10500 standard [11].

pH: pH is a basic physiochemical parameter. The esteem pH of savouring water the review territory differs from 6.53-8.42. This outcome shows that the pH of the considerable number of tests were under the BIS limits i.e. 6.5-8.5. 96% of the total samples have the pH value in the range given by BIS and rest is below the range.

TDS: It is total dissolved solids found in he given water sample. Its value in groundwater tests was in the scope of 230-1372 mg L^{-1}, which was under BIS, 2012 restrict i.e. 2000 mg L^{-1} and Where TDS >1000 mg L^{-1} leads to corrosion [12].

Electrical conductivity: Conductivity gives the possibility of particles present in given specimen. Conductivity in the drinking water test differs from 487-1792 µmhoscm^{-1}, which demonstrates the nearness of tremendous measure of particles in test due to hardness or overwhelming metals. It seems that the EC is positively correlate to the TDS**.** High values of TDS in Drinking water have been reported by many Authors in different parts of India [13-15]. The range of EC for Agriculture water as given by BIS (IS: 10500:1991) is excellent for < 250 µmhoscm^{-1} to vary bad at above 4000 µmhoscm^{-1}[16] (Table 2).

Table 2. Concentration of various parameters in Drinking water of India Mark-II hand pumps (mg L^{-1}) except for Electrical conductivity (µmhos cm^{-1})

S.No	Sample	Ph	TDS	ORP	E.C	Alkalinity	Cl content	T.H	TOC	Mn	Fe	Ni	Mg	Pb	Cd	B	Al	Se
1	R1	6.64	497	414.8	1019	500	124.2	500	15.2	0.098	0.28	ND	23.34	0.002	0.038	2.11	0.01	1.35
2	R2	6.7	497	395.4	846	700	71	350	13.3	0.001	0.23	ND	13.87	0.001	0.031	3.6	ND	1.26
3	R3	7.72	500	317.8	1463	800	159.7	450	10.4	0.004	0.34	ND	18.35	0.005	0.034	1.67	0.08	1.67
4	R4	6.59	502	319.7	608	500	71	430	8.28	0.084	ND	ND	17.85	0.004	0.036	1.98	0.01	1.82
5	M1	7.52	493	321.9	1157	750	106.5	450	9.16	0.075	0.04	ND	19.98	0.004	0.05	0.97	0.02	1.24
6	M2	6.54	495	312.2	1161	650	142	450	19.4	0.035	0.08	ND	17.58	0.002	0.043	0.47	0.06	1.6
7	M3	6.66	493	313.5	642	500	99.4	250	19.3	0.075	0.012	ND	28.93	ND	0.024	0.58	0	1.43
8	M4	6.27	497	310.4	737	400	142	400	7.38	0.092	0.124	ND	27.21	0.003	0.061	4.22	ND	1.21
9	BM1	6.63	499	318	894	650	88.75	400	9.18	0.102	0.286	ND	23.65	0.001	0.048	3.24	0.01	1.72
10	BM2	6.59	334	196	662	600	71	350	11.9	0.11	0.35	ND	21.56	0.002	0.031	3.98	0.02	1.4
11	BM3	6.53	301	197.2	616	550	56.8	320	6.24	0.083	0.37	ND	24.86	0.001	0.039	3.69	0.1	1.74
12	BM4	6.8	230	198.1	487	700	53.25	400	11.2	0.097	0.482	ND	19.72	ND	0.043	3.47	0.03	1.34
13	BR1	8.1	390	388.2	790	750	106.5	300	16.4	0.152	0.56	ND	18.52	ND	0.041	0.97	0.01	1.82
14	BR2	8.42	497	392	1000	900	46.33	250	12.5	0.179	1.64	ND	26.74	0.003	0.061	4.99	0.01	1.86
15	BR3	7.08	552	409	1112	750	227.2	200	9.52	0.098	0.125	ND	18.95	0.002	0.05	2.67	0	1.29
16	BR4	7.82	718	394.1	1427	1000	177.5	190	8.79	0.124	1.28	ND	24.52	0.001	0.038	1.59	0.05	1.62
17	S1	7.05	1372	319.1	1792	450	42.6	400	14.6	0.138	0.982	ND	28.64	0.001	0.037	2.95	0.13	1.68
18	S2	8.1	457	314.5	1002	1050	60.35	550	17.5	0.156	4.21	ND	17.26	0.003	0.036	4.08	1.2	1.62
19	S3	6.98	366	366	1094	650	337.2	300	19.3	0.099	0.682	ND	25.81	ND	0.049	2.87	0.1	1.72
20	S4	7.3	580	411	1189	650	56.8	280	13.9	0.147	0.667	ND	19.82	0.001	0.05	3.53	0.12	1.69
21	G1	7.2	489	328.4	748	450	35.5	290	17.7	0.001	1.53	ND	15.72	0.001	0.04	1.85	0.07	1.6
22	G2	7.4	344	323.6	1040	550	53.25	250	19.9	0.072	2.01	ND	21.86	0.002	0.049	4.19	ND	1.74
23	G3	7.42	334	309.7	958	500	31.95	210	13.9	0.023	0.23	ND	20.87	ND	0.049	3.89	0.15	1.6
24	G4	7.1	445	294.1	666	550	35.5	200	12.9	0.001	0.735	ND	25.27	0.004	0.047	4.15	0.05	1.65
25	G5	8	485	287.7	678	500	39.05	230	16.8	0.019	0.475	ND	26.35	0.005	0.048	3.68	0.08	1.54
26	G6	7.8	445	297.4	888	550	46.15	220	15.9	0.016	5.14	ND	21.15	0.001	0.053	3.95	0.04	1.65

ND-Not Detected, R-Ranchar, M-Mangrouli, BM-Bamnauli, BR-Barnawa, S-Sirsali, G-Gangnauli.

Alkalinity: It is the measure of nearness of carbonate, bicarbonate and hydroxide particles in the specimen. The present review shows that alkalinity go 400-1050 mg L^{-1}. The point of confinement of possibility of Alkalinity in drinking water as indicated by BIS, 2012 standard is 600 mg L^{-1}. So this review shows that 54% samples have the alkalinity above than BIS limit, rest are under the limit. It is expected the particles exhibit in water.

Chloride: The measure of chloride substance in the examples ranges from 31.95-337.2 mg L^{-1} which was far underneath as far as possible i.e 1000 mg L^{-1} as given by BIS, 2012 standard. The entire sample showed the alkalinity under the BIS limit.

Hardness: Foam framing limit of water is the measure of its hardness and delicateness. Chlorides, sulphates, carbonates and bicarbonates of calcium and magnesium are in charge of the hardness. The hardness in the review territory goes 190-550 mg L^{-1}, which was inside the admissible furthest reaches of 600 mg L^{-1} as given by BIS, 2012 standard. Calcium and magnesium are plentiful in nature and basic for person for their wellbeing reason. Higher level of calcium is responsible for hardness and desire amount is responsible for proper functioning of bone.

TOC: It is the measure of total organic carbon present in the water sample. There is no acceptable or permissible limits mention by BIS in terms of TOC. According to US EPA the value of TOC should be less than 2 mg L^{-1} in drinking water. All the samples from the study area have the TOC value above as prescribed by US EPA [**17**].

A Balanced eating routine of human incorporates the minerals too. These minerals are required by our body for appropriate capacity. These are called follow components. These components are constantly disintegrated in water in moment amount. The inadequacy of these basic or follow component cause genuine wellbeing risk. Incorporated these basic components various components are likewise revealed in drinking water which is because of permeation of such defiled water. These hazardous elements are called heavy metals. An arrangement of 9 follows components i.e. Fe, Al, Se, B, Mn, Cd, Mg, Ni, Pb having lethal impact on human wellbeing was investigated with ICP. The convergence of these components in ground water test is given in table 2 and their correlations factors are given in table 4.

Magnesium: The convergence of magnesium changed from 13.87-28.93 mg L^{-1}. The outcomes demonstrate that the magnesium fixation in all examples was beneath as far as possible 30 mg L^{-1} as given by BIS, 2012.

Iron: It is a fundamental component which lack causes Anemia. In any case, its fixation in the drinking water ought not to surpass the farthest point of 1 mg L^{-1}, which is allowable cut-off for Fe focus. The Fe centralization of 65% examples in the review territory were surpasses the farthest point as suggested by BIS, 2012. High concentration of Fe also reported by many authors in the selected region as well as other part of West U.P [**18, 19**]. High centralization of Iron is in charge of conjunctivitis. The high concentration of Fe will be because of the corrosion of hand pump pipes by dissolution of corrosion scale [**20**].

Aluminium: The concentration of Aluminium in the study area samples were 0.012-5.14 mg L^{-1}, where the permissible limit given by BIS is 0.2 mg L^{-1}. The result shows that the concentration of Al in one sample is above the BIS standard where in 3 samples out of 26 Al concentration was not detected.

Manganese: It is a fundamental component which is found in plenitude. Unsanitary deposits are the prime cause of Mn pollution [**21**]. Its lack can bring about birth deformity, skeleton issue and so on. The Mn focuses ranges from 0.001-0.179 mg L^{-1}. The BIS, 2012 furthest reach of Mn fixation in ground water is 0.3 mg L^{-1}. All the samples have the Mn concentration under the BIS limit. High introduction of Mn cause nerve issue, Insomnia, Parkinson malady.

Selenium: It is utilized as a healthful nourishes added substance for poultry and domesticated animals, vulcanizing operator in rubber, in pesticide definitions, and as a quickening agent and creation. According to EPA most shakes and soil contain selenium. It's discharged into air, water, and soil actually and when it's fabricated. Selenium can enter the air when coal and petroleum powers are singed (ignition), metal is purified different metals are refined Selenium additionally originates from keep running off and modern wastewater from copper and lead refineries, metropolitan wastewater, perilous waste transfer locales (https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations). Selenium is also as a constituent of fungicides [22]. Selenium is a toxic trace element which acceptable limit in drinking water is 0.01 mg L^{-1} and has no relaxation in permissible limit (BIS-2012). All the 26 sample shown the selenium concentration at the level where it cross the limit recommended by BIS, 2012. Selenium cause a series of health effect including brittle hair, deformed nails, rashes, swelling of skin birth defect and severe pains. (htpp://www. lenntech. com/periodic/elements/se.htm). All the 26 ground water tests having the Se esteem over as far as possible. High presentation of Se can bring about death.

Boron: Boron mixes are discharge into water from mechanical and household effluents. The most extreme reasonable point of confinement of B is 1 mg L^{-1} [7]. The Boron focus in the chose test ranges 0.47-4.99 mg L^{-1}. These outcome demonstrate that the B fixation in 85 % examples were over as far as possible. High admission of Boron can cause gastrointestinal unsettling influence, peevishness, irritation, blockage and so on [23]. (https://processresearchortechinc selenium.weebly.com/uses-of-selenium.html). Drinking water is the major source of Boron intake. According to WHO the amount of Boron taken is 0.2-0.6 mg day^{-1} via drinking water [24].

Cadmium: This is a cancer-causing component which can be found in ground water because of erosion of aroused pipe or by permeation of modern emanating. One wellspring of cadmium entering our surroundings is phosphate metal utilized as a part of generation of phosphate manure [25]. It is also used extensively in electroplating [22]. The BIS, 2012 admissible breaking point of Cd is 0.01 mg L^{-1}. The Cd focus in the ground water of the review range was 0.024-0.61 mg L^{-1} which shows that the entire example crosses as far as possible. Gigantic presentation to Cd can bring about unfavorable wellbeing impact in particular kidney disappointment, softening of bone, mental issue barrenness, DNA harm and Cancer. Cadmium is likewise connected with bone imperfections, viz; osteocalcin, osteoporosis and unconstrained cracks, expanded circulatory strain and myocadiac dysfunctions [26].

Aluminium: Aluminium is most abundant element found in earth crust. The BIS permissible recommendation of Al concentration in drinking water is should be less than 0.2 mg L^{-1}. 4 % of drinking water sample from the present study have the concentration higher than the above limit.

Sources of heavy metals in the groundwater samples: The nature of ground water sources are influenced by the qualities of the media through which the water goes to the ground water zone of immersion [27, 28], thus, the overwhelming metals released by enterprises, traffic, civil squanders, dangerous waste locales just as from composts for rural purposes and unintentional oil spillages from tankers can result in a consistent ascent in sullying of ground water. Moreover, ground-water quality is impacted extensively by the nature of the recharge source. Varieties in natural and human exercises reflect spatial varieties of the aquifer and the hydro chemical parameters of the groundwater. Pollution sources are classified as point sources and diffuse sources (non-point sources). Point sources are sources that can be clearly identified and pinpointed (such as landfill leachate). Diffuse sources can't be pinpointed and are dispersed over an extensive surface territory (application of fertilizers and pesticides in agriculture) [29]. In this way, as notice above there can be several medium through these elements passed to the Ground water Aquifers as discussed below.

As far as the source of these elements in the drinking water samples are concerned the simple postulation would be that Fe will be because of the corrosion of hand pump pipes by dissolution of corrosion scale as discussed earlier because Fe is the basic material of drilled parts of hand pumps and tube wells. Due to prolonged submergence under unfavorable condition these pipes undergo Redox reaction and form brownish layer of its Oxide [21].

The reason of high concentration of Cd in the drinking water samples will be the same. It may be due the corrosion of Galvanized pipes. As soon as the hand pumps pipes become old, they form corrosion and release specific amount of Cd in the water because Cd used in the process of Galvanization of iron pipes [23]. Another source of Cd in environment is because of its presence in fertilizers and pesticides as an impurity. The specific quantity of Cd in some highly used fertilizer is for Copper sulphate (0.21 mg kg^{-1}), Iron sulphate (0.03 mg kg^{-1}), Urea (0.01 mg kg^{-1}), Superphosphate (2.22 mg kg^{-1}) and for pesticides like Antracol (1.94 mg kg^{-1}), Saturn-G (1.48 mg kg^{-1}), Ordram (1.38 mg kg^{-1}) [30].

High amount of Se in the drinking water samples may be due to the use of Se-rich fertilizer in the past times. Its tendency is to go to the groundwater. It is bio accumulative and passed up within food chain [23]. Another way of Se entered in the environment due to use in photocopying process. (https://processresearchortechincselenium.weebly.com/uses-of-selenium.html)

Mn found abundantly in earth crust and usually occurs together with Iron [31].

Table 3. Range of concentration of various parameters in Ground water samples and their comparison with BIS (2012) with their Statistical Analysis

S. No	Parameters	Range in Ground water		Sample no having concentration		BIS Limit- 10500:2012		Statistical Analysis of Results				
		Min.	Max.	Min.	Max.	Acceptable	Permissible	Mean	Median	Mode	SD	SE
1	pH	6.27	8.42	M4	BR2	6.5-8.5		7.19	7.09	6.590	0.596	0.116
2	TDS	230	1372	BM4	S1	500	2000	492.76	497	497	204.5	40.115
3	ORP	196	414.8	BM2	R3	-	-	324.99	318.55	-	61.85	12.12
4	E. C	487	1792	BM4	S1	-	-	949.07	926	-	304.24	59.66
5	Alk	400	1050	M4	S2	200	600	638.46	625	500	166.91	32.73
6	Cl	31.95	227.2	G3	BR3	250	1000	95.44	71	71	70.35	13.79
7	T. H	190	550	BR4	S2	200	600	331.53	310	400	103.13	20.22
8	TOC	6.24	19.89	BM3	G2	-	-	13.48	13.58	-	4.086	0.801
9	Mn	0.001	0.179	R2,G1,G4	BR2	0.1	0.3	0.080	0.088	0.001	0.053	0.010
10	Fe	0.012	5.14	M3	G6	0.3	NR	0.914	0.475	0.23	1.255	0.246
11	Ni	-	-	-	-	0.002	NR	-	-	-	-	-
12	Mg	13.87	28.93	R2	M3	30	100	21.860	21.355	-	4.099	0.803
13	Pb	ND	0.005	M3,BM4, BR1,S3,G3	R3	0.01	NR	0.0023	0.002	0.001	0.0013	0.0002
14	Cd	0.024	0.061	M3	M4	0.003	0.01	0.0433	0.043	0.05	0.0089	0.001
15	B	0.47	4.99	M2	BR2	0.5	1	2.897	3.35	0.97	1.282	0.251
16	Al	ND	1.2	R2,M4,G2	S2	0.03	0.2	0.101	0.05	0.005	0.243	0.047
17	Se	1.21	1.86	M4	BR2	0.01	NR	1.571	1.62	1.6	0.193	0.378

Statistical analysis: Correlation matrix was prepared to find out relation between different parameters and their results have shown in Table 2. The pH is positively correlated with TDS (r=0.045405), ORP (r=0.299042), EC (r=0.28569), Alkalinity (r=0.568903), TOC (r=0.229332), Mn (r=0.184807), Fe (r=0.516723), Pb (r=0.293363), Cd (r=0.252077), B (r=0.11358), Al (r=0.323597), Se (r=0.405246) and negatively correlated with Cl content (r= -0.14625), Hardness (r= -0.2742), and Mg (r=-0.05646).

TDS is positively correlated with ORP (r=0.229332), EC (r=0.713974), Hardness (r=0.082154), Mn (r=0.231353), Fe (r=0.00963), Mg (r=0.298782), Al (r=0.005938) and Se (r=0.07121). It is negatively correlated with Alkalinity (r= -0.06112), Cl content (r=-0.02515), TOC (r=-0.02098), Pb (r=-0.21788), Cd (r=-0.12143) and B (r=-0.15329).

ORP is positively correlated with EC (r=0.467079), Alkalinity (r=0.28496), Cl content (r=0.369757), TOC (r=0.176073), Mn (r=0.227057), Cd (r=0.169432) and Se (r=0.062036) and negatively correlated with Hardness (r=-0.13113), Fe (r=-0.01491), Mg (r=-0.12249), Pb (r=-0.14678), B (r=-0.22546) and Al (r= -0.04734).

Electrical Conductivity is positively correlated with Alkalinity (r=0.311021), Cl content (r=0.309138), Hardness (r=0.122522), TOC (r=0.059474), Mn (r=0.210679), Fe (r=0.060853), Mg (r=0.066796), Cd (r=0.0269), Al (r=0.097993), Se (r=0.149376) and negatively to Pb (r= -0.14785) and B (r= -0.21275).

Alkalinity is positively correlated with Cl content (r=0.245206), Hardness (r=0.118408), Mn (r= 0.423332), Fe (r= 0.259438), Pb (r=0.070279), Al (r=0.465334) and Se (r= 0.12341). It is negatively correlated with TOC (r=-0.10959), Mg (r= -0.27832), Cd (r=-0.03763), B (r=-0.05188).

Cl content is positively correlated with Hardness (r=0.035752), Mn (r=0.131694), Mg (r=0.074967), Pb (r=0.05204), Cd (r=0.055594) and it is negatively correlated with TOC (r= -0.01047), Fe (r=-0.2604), B (r=-0.36536), Al (r=-0.12214), Se (r=-0.14674).

Hardness is positively correlated with Mn (r=0.171828), Pb (r=0.186491), Al (r=0.408112) and negatively to TOC (r=-0.09895), Fe (r=-0.04286), Mg (r=-0.28469), Cd (r= -0.27652), B (r=-0.21984), Se (r=-0.19089).

TOC is positively correlated with Fe (r=0.310344), Al (r=0.248683) and Se (r=0.192687). It is negatively correlated with Mn (r= -0.12455), Mg (r= -0.04093), Pb (r= -0.08722), Cd (r= -0.13631) and B (r=-0.13628).

Table 4. Correlation matrix of various parameters

para meter	Ph	TDS	ORP	Elec. Cond	Alk	Cl cont	Hard	TOC	Mn	Fe	Mg	Pb	Cd	B	Al	Se
pH	1															
TDS	0.045405	1														
ORP	0.299042	0.304413	1													
E. C	0.28569	0.713974	0.467079	1												
Alk.	0.568903	-0.06112	0.28496	0.311021	1											
Cl	-0.14625	-0.02515	0.369757	0.309138	0.245206	1										
T.H	-0.2742	0.082154	-0.13113	0.122522	0.118408	0.035752	1									
TOC	0.229332	-0.02098	0.176073	0.059474	-0.10959	-0.01047	-0.09895	1								
Mn	0.184807	0.231353	0.227057	0.210679	0.423332	0.131694	0.171828	-0.12455	1							
Fe	0.516723	0.00963	-0.01491	0.060853	0.259438	-0.2604	-0.04286	0.310344	0.071512	1						
Mg	-0.05646	0.298782	-0.12249	0.066796	-0.27832	0.074967	-0.28469	-0.04093	0.269933	-0.13212	1					
Pb	0.293363	-0.21788	-0.14678	-0.14785	0.070279	0.05204	0.186491	-0.08722	-0.22041	-0.16037	0.068081	1				
Cd	0.252077	-0.12143	0.169432	0.0269	-0.03763	0.055594	-0.27652	-0.13631	0.113831	0.14324	0.218483	0.111247	1			
B	0.11358	-0.15329	-0.22546	-0.21275	-0.05188	-0.36536	-0.21984	-0.13628	0.094563	0.348559	0.206837	-0.05971	0.456716	1		
Al	0.323597	0.005938	-0.04734	0.097993	0.465334	-0.12214	0.408112	0.248683	0.249288	0.553806	-0.24367	0.078245	-0.1578	0.266216	1	
Se	0.405246	0.07121	0.062036	0.149376	0.12341	-0.14674	-0.19089	0.192687	0.214748	0.343288	0.098746	-0.03716	0.079874	0.084653	0.084059	1

Mn is positively correlated with Fe (r=0.071512), Mg (r=0.269933), Cd (r=0.113831), B (r=0.094563), Al (r=0.249288) and Se (r=0.214748) while it is negatively correlated with Pb (r= -0.22041).

Fe is positively correlated to Cd (r=0.14324), B (r=0.348559), Al (r=0.553806) and Se (r=0.343288). It is negatively correlated with Mg (r= -0.13212) , Pb (r= -0.16037). Mg is positively correlated with Pb (r=0.068081), Cd (r=0.218483), B (r=0.206837), se (r=0.098746) and negatively correlated with Al (r= -0.24367).

Pb is positively correlated with Cd (r=0.111247) and Al (r=0.078245) while negatively correlated with B (r= -0.05971) and Se (r= -0.03716). Cd is positively correlated with B (r=0.456716), Se (r=0.079874) and negatively correlated with Al (r=-0.1578).

Boron is positively correlated with Al (r=0.266216) and Se (r=0.084653) Where Al is positively correlated with Se (r=0.084059).

APPLICATION

The above analysis and its outcome are useful to point out the polluted Drinking water Resources and alert the people who are living in the catchment of such a polluted River and also motivate for taking necessary measures for their future and avoid contaminated water for drinking purpose.

CONCLUSION

On the basis of this study the ground water samples found contaminated by several elements. Most of the Water samples from the study area exceed the BIS limit in several physiochemical parameters as well as in Heavy metals. This contamination of ground water may be due the pollution of nearby water bodies like Krishni River. Implementation of Several acts should be done in this area to save this natural resource. Drinking water in the close proximity of Krishni River should be pre-treated before use. It should be recommended that all the point sources should be properly treated before discharging their waste into Krishni River. Otherwise the condition of river water becomes worse and ground water of Krishni River catchment contaminated by poisonous elements in huge amount.

Conflict of Interest: The authors declare no conflict of interest.

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