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Assessment of Groundwater Quality Regarding Chloride Concentration: A Case Study in Kolar District, Karnataka State, India

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ABSTRACT

Water quality assessment and management is one of the most important aspects of water security because it is the key to ensure viable growth. The studies purpose and goal is to determine whether the water is suitable for consumption or safe for the environment. Five different talukas of Kolar District, Karnataka, India was chosen as the study area because groundwater has been overexploited in all its five talukas since 2011 due to erratic and scanty distribution of rainfall hence quality is important. Therefore an holistic approach regarding concentration of chloride was employed to investigate the quality of groundwater. Totally, fifty groundwater samples were collected seasonally from fifty different borewells distributed all over the five different talukas of Kolar District and the parameters such as chloride along with other parameters of groundwater were analyzed. The analyzed results reveals that few of the samples were shown higher concentration than the permissible limit and few of the samples were shown concentration of within the permissible limit. Therefore, it is recommended to treat the water adequately prior to its consumption.

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Introduction:

Although the threshold changes based on the surrounding cations, the World Health Organization (WHO, 1996) has published standards for the quality of drinking water, noting that a chloride level above 250 mg/L can generate detectable taste in water. Based on the potential effects of chloride on human health, no recommended levels for chloride in drinking water have been developed. Chloride ions are essentially required for plants and animals. They are stored in plants and animal bodies in the form of sodium chloride. Low concentration of chlorides seen in unpolluted pure water i.e. lower than 10 mg/L (APHA, 1998). High concentration of chloride seen in water containing the effluents received from sewage, human excreta particularly urine has high amount of chlorides (Manual for water testing kit 1997, KSPCB). The quality of groundwater in the study area is influenced by factors such as agricultural activities, geological formation, and local environmental conditions. Sodium and potassium concentrations in the area were found to be within permissible limits. However, chloride concentration was found to exceed the permissible limit for drinking water suggested by BIS (1991) as well as WHO (1996), as reported by Sayyed and Bhosle (2011). The presence of high chloride concentration in groundwater is a sign of sewage water contamination, highlighting the need for the installation of sewage water treatment plants and immediate lining of sewage drains and reinstallation of broken sewer pipelines (Sameer et al., 2011). Rising sea levels and overexploitation of groundwater as a source of clean water can lead to the intrusion of saltwater into underground water sources. When chloride levels exceed about 250 mg/L, water may have a detectable taste and be unsuitable for human consumption (Sundaryanto and

Wilda 2017). The presence of chloride in groundwater is attributed to the mixing of shallow karst water with deep saline fossil water, according to Mohamoud et al. (2013). The contamination of groundwater quality is primarily caused by geogenic salinity and sea water intrusion, but anthropogenic pollution also plays a significant role. Hence, the chloride concentration in lower aquifers is higher than in the upper aquifers, it is due to the coral reef limestone deposition and water type evolved towards $Ca(HCO_3)_2$(Kristine et al.,2015). the buildup of chloride in shallow groundwater is due to the discharge of industrial wastewater without proper treatment and the incorrect use of fertilizers, which add to the contamination of groundwater with chloride (Xiu *et al*.,2015). The main issue of groundwater contamination with chloride (salt) in the study area, which is Indonesia's coastal region, is due to the static fossil water and dynamics of sea water intrusion. The most appropriate methods of control in this region are artificial recharge and extraction barrier, according to Purnama and Marfai (2012). If the samples contain a large amount of salts and chloride ions, the water can become hard and unsuitable for drinking purposes. Similarly, the chloride ions hardened as its temperature was low. Finally, recommendation was to use saline water after boiling (Fazal-ur-Rehman,2017)). Intensive agriculture and private industrialization is characterized by a significant chlorinated solvent contamination in groundwater (Federica *et al*.,2015). The extraction of oil and gas from deep aquifers has led to both risks and benefits, including valuable data and potential groundwater contamination with salts, according to Mary and Robert (2016). One common problem related to freshwater coastal aquifers is seawater intrusion, which can lead to deterioration of groundwater quality due to high chloride levels, as noted by Assad et al. (2020). The overuse and exploitation of groundwater resources in arid and semi-arid coastal zones have a significant impact on the intrusion of seawater and subsequent contamination of groundwater (Nawal and Kristine, 2018). High levels of sodium and chloride in water can have various negative effects, such as affecting the taste and causing watering in certain plants, as well as increasing the corrosivity of water, which can have an impact on household plumbing. Additionally, a low sodium diet is recommended for individuals with high blood pressure and other medical conditions, which is often only possible with water containing less than 20 mg/L of sodium. Therefore, it is essential to focus on sustainable water resource management to prevent contamination of groundwater with saltwater intrusion. (Luca et al., 2017). Climate change and increasing anthropogenic pressure widely affect the seawater intrusion and causes chloride contamination of groundwater (Maurizio and Kristine, 2019). Population explosion, intensifying groundwater exploitation and rise of sea level has greater impact on salinization of groundwater (Marmar,2018). Chloride concentration was beyond the permissible limit. The study concluded that taking precautionary measures before consuming water in the Bhavnagar region is essential to avoid any potential adverse health effects on human beings. (Mishra et al., 2009). The chloride content study area samples were in higher range than permissible limit (Venkatachalam *et al*.,2010).

Field Study:

The study was conducted in Kolar District, which covers an area of 4,012 square kilometers and has a population of approximately 16.50 lakhs. The district is comprised of 5 Talukas, namely Kolar, Bangarpet, Malur, Mulbagal, and Srinivaspur, and is situated between north latitude 12o45'54" and east latitude 77050'29".

It consists of 1798 villages and 156 gram Panchayats, with the majority of the population relying on agriculture as their primary occupation, which is mainly supported by borewell water. The district experiences a semi-arid climate with tropical monsoon and tropical weather, featuring hot summers and mild winters. The study area does not have any significant surface water sources, and the primary source of drinking water is through borewells (groundwater).

Resources and Techniques:

Throughout the course of five distinct talukas of Kolar District, fifty different bore wells were used to gather a total of fifty groundwater samples and the parameters such as chloride along with other parameters of groundwater were analyzed.

Chloride is a common inorganic anion found in both water and wastewater. Chloride ions are more commonly found in wastewater than in raw water due to the presence of sodium chloride (NaCl) in the diet, which is excreted unchanged in the digestive system. Chloride was estimated by Argentometric method (APHA, 2000).

50 ml, or an aliquot volume, diluted with distilled water to a level of about 50 ml. If the samples are highly colored, it was removed with charcoal.

Samples were titrated directly in pH range 7.0 and 10.0. pH of the samples was adjusted between 7 and 10 with calcium carbonate ($CaCO_3$) powder was added as indicator. The sample was titrated with a standard solution of silver nitrate (AgNO3) until a brick-red endpoint was reached.

Results and discussion :

Chloride is anion that is most commonly associated with salt such as chlorides (common table salt as diet article) and passing through the digestive system unaltered. Often it is also associated with potassium, calcium and magnesium in nature and are called as potassium chloride, calcium chloride and magnesium chloride respectively. All natural water contains chlorides in varying degree. Upland and mountains have low level of

chlorides. While rivers and groundwater may have high levels of chlorides, the primary source of salts in groundwater is from rock minerals that contain chlorides, such as sodalite and chloropalite. These minerals are present in very small amounts in igneous and metamorphic rocks, as well as liquid inclusions. Other sources are either from atmospheric source (run off water include inorganic fertilizers, septic tanks effluent, landfill leachate and industrial waste water source) and Halite and other evaporating deposits in sedimentary rocks cause seawater contamination. The presence of chloride in groundwater is commonly associated with sodium chloride, but the concentration of chloride can exceed its expected levels due to a process called base exchange phenomenon. In general, chloride shows seasonable concentrations and are not harmful to mankind. A water with chloride above 250 mg/L causes salty taste to water and unfit for drinking. Depending upon salt toleration range the animals are classified into two types such as stenohaline (cannot tolerate wide range of salt concentration) and euryhaline (have wide range tolerance of salt concentration) animals. Abnormal concentration of chloride is due to sewage pollution, salting of certain types of trees such as coconut and saline residuals leaching in the soil (Karanth,1977).

Chloride concentration varied from source to source and season to season. Chloride concentration values during pre-monsoon season (summer, March-May) of 2014 exhibited minimum as 750.0 milligram per Liter also maximum as 561.0 milligram per Liter. Although during same season of 2015 exhibited minimum as 24.0 mg/L and maximum as 559.0mg/L. Similarly, the chloride concentration values during post-monsoon season (October-December) of 2014 exhibited minimum as 20.0 mg/L and maximum as 577.0mg/L. While during same season of 2015 exhibited minimum as 20.0 milligram per Liter and maximum as 420.0 milligram per Liter. When compared with total average values, the pre-monsoon season of 2014 exhibited as 312.6 mg/L, whereas same season of 2015 exhibited 248.1mg/L. Similarly, the post-monsoon season of 2014 exhibited as 248.8 mg/L, whereas same season of 2015 exhibited as 121.6 mg/L. It is clearly indicated that the concentration of chloride values was decreasing slightly season to season and year to year. It is mostly due to increase in rainfall in the year 2015, which was normal than the higher and improvement in the water level of borewells that pronounces the proverb "solution for pollution is dilution".

Chloride concentration was recorded in all 50 sampling sources of the Kolar District with reference to all five selected talukas and presented in the following table.

Table shows seasonal variations in the concentration of chloride in study location Kolar District for the time periods prior to and following the monsoon season, 2014 – 2015

Sl.No.	Sources Number	Pre-monsoon season 2014 March-May	Post-monsoon season 2014 October-December	Pre-monsoon season 2015 March-May	Post-monsoon season 2015 October-December	Average
1	I	285	287	321	110	250.75
2	II	190	339.5	445	210	296.125
3	III	500	499.2	210	70	319.8
4	IV	455	461	170	60	286.5
5	V	136	136	80	160	128
6	VI	75	80	89	80	81
7	VII	544	484	70	40	284.5
8	VIII	285	285	461	102	283.25
9	IX	368	370	160	125	255.75
10	X	368	390	330	80	292
11	XI	235	236	236	40	186.75
12	XII	358	60	359	42	204.75
13	XIII	520	30.6	525	300	343.9
14	XIV	150	140	550	250	272.5
15	XV	500	360	502	370	433
16	XVI	300	301	135	180	229
17	XVII	125	140	155	152	143
18	XVIII	150	155	185	102	148
19	XIX	221	250	110	124	176.25
20	XX	223	246	222	50	185.25
21	XXI	552	79	450	80	290.25
22	XXII	298	320	300	60	244.5

23	XXIII	345	70	346	80	210.25
24	XXIV	285	60	290	61	174
25	XXV	521	523	178	80	325.5
26	XXVI	500	50	400	40	247.5
27	XXVII	75	80	81	51	71.75
28	XXVIII	155	156	160	120	147.75
29	XXIX	402	403	6	52	215.75
30	XXX	499	500	50	60	277.25
31	XXXI	150	140	150	155	148.75
32	XXXII	146	150	169	150	153.75
33	XXXIII	148	120	149	120	134.25
34	XXXIV	356	80	359	70	216.25
35	XXXV	109	68	115	250	135.5
36	XXXVI	300	350	280	50	245
37	XXXVII	81	92	400	52	156.25
38	XXXVIII	345	93	350	91	219.75
39	XXXIX	80	100	31	20	57.75
40	XL	133	400	221	45	199.75
41	XLI	554	400	559	420	483.25
42	XLII	422	420	200	325	341.75
43	XLIII	440	261	51	250	250.5
44	XLIV	529	535	536	0	400
45	XLV	240	20	250	21	132.75
46	XLVI	540	252	240	251	320.75
47	XLVII	401	450	402	40	323.25
48	XLVIII	561	577	250	70	364.5
49	XLIX	126	150	91	280	161.75
50	L	350	290.1	24	90	188.525

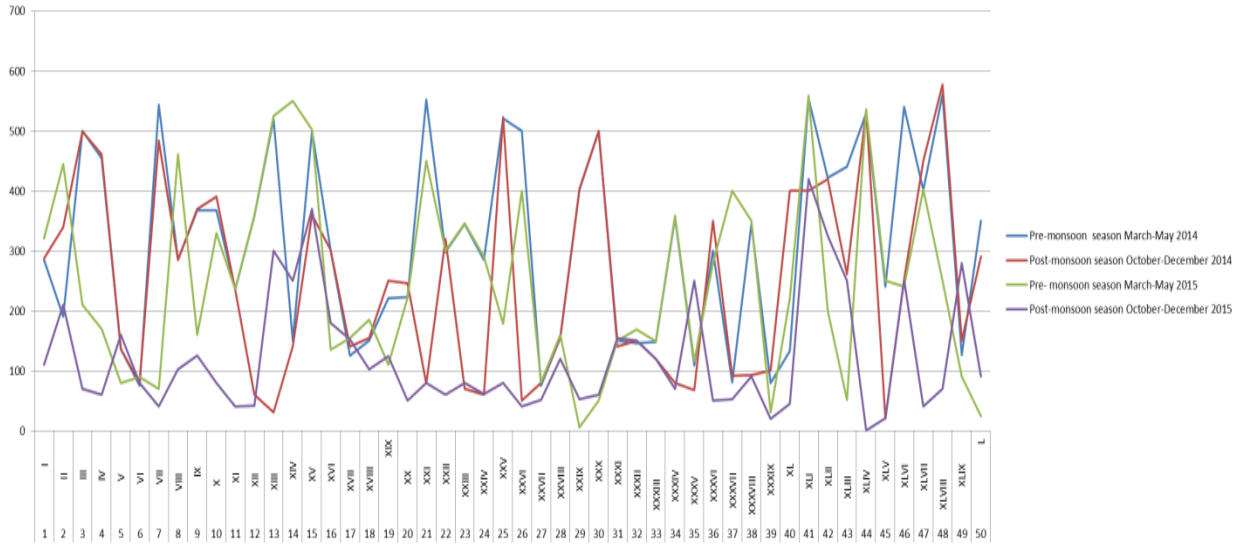

Fig. Pre-monsoon season and post-monsoon season fluctuations in the concentration of chloride from various sources in the research area Kolar District, 2014 - 2015.

Consider: X-axis In graph signifies source number and Y-axis signifies Chloride concentration level.

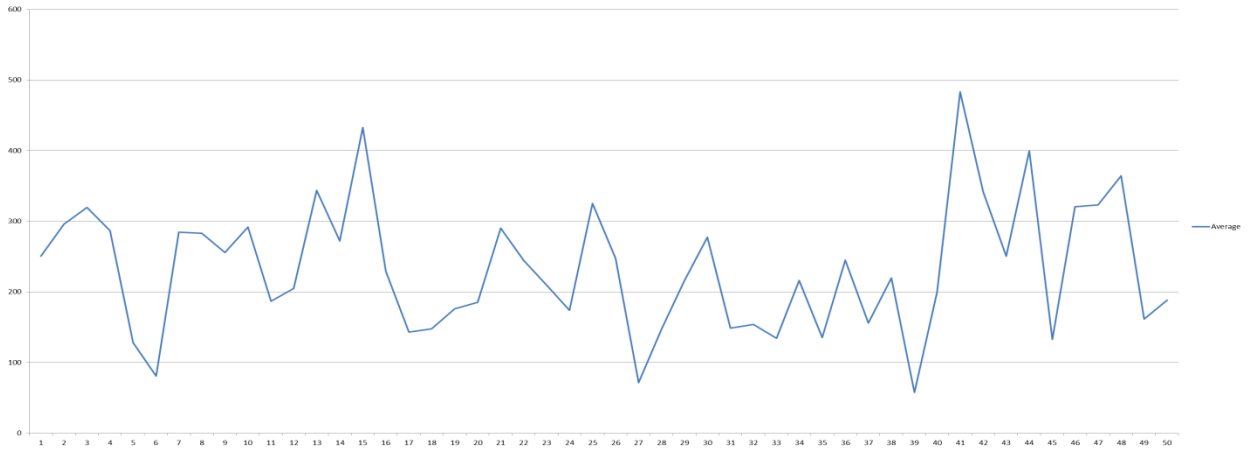

Fig. Showing the pre-monsoon and post-monsoon variations in chloride content caused by various sources in the Kolar District research region in 2014 – 2015.

Consider: X-axis in the graph represents source number and Y-axis signifies Chloride concentration level.

Conclusion:

The analyzed results reveals that few of the samples has higher concentration than the permissible limit and few of the samples has concentration of within the permissible limit. Hence, based on the high chloride levels found in the groundwater samples, it is recommended that proper treatment methods should be employed to remove the excess chloride before the water is consumed. It is further suggested that encourages the best practices on traditional methods of conservation of water, crop rotation programs with less water intense plants and disseminates it with a view to bringing awareness and replication in other areas.

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