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A PAPER ON "GEOCHEMICAL ANALYSIS FOR FLUORIDE IN GROUNDWATER OF MALAPRABHA RIVER BASIN USING GIS"

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ABSTRACT
This study was conducted to evaluate fluoride contamination in ground water in part of Malaprabha river basin using GIS where ground water is the main source of drinking as well as irrigation. The water samples are collected manually from the bore wells and at each sampling location GPS is used to point out the location. An integrated analysis of chemical parameters especially of fluoride is done as per standard guideline values. Among the 42 collected samples from study area 8 samples were not potable due to high fluoride concentration, one sample was not potable due to Total Dissolved Solids (TDS), and six samples were not potable due to hardness. A correlation study of water quality parameters with fluoride content was performed on groundwater samples of Hungund Taluk, of Bagalkot district. Fluoride has a significant positive correlation with bicarbonate ions and with sodium (Na+) but higher negative correlation with calcium (Ca2+). The rock formation of the study area consists of fluoride bearing minerals; an ion exchange process which takes place between ground water and the rock strata has been studied. Ion exchange between Ca2+ and Na+ due to the movement of groundwater may also result in high F- associated with high Na+ and low Ca2+ concentration. The ground water quality information maps of the entire study area were prepared using GIS spatial analysis for all the parameters.

KEYWORDS: Ground water, Fluoride, Ion exchange process, GIS.

INTRODUCTION
Water is the most valuable and vital resource for sustenance of life and also for any developmental activities like drinking and municipal use, for irrigation, to meet the growing food and fiber needs for industries, power generation, navigation and recreation. The availability of a water supply adequately in terms of both quantity and quality is essential to human existence. The groundwater quality is equally important as that of quantity. The demand for water has increased over the years and this has led to water scarcity in many parts of the world. The situation is aggravated by the problem of water pollution or contamination. India is heading towards a freshwater crisis mainly due to improper management of water resources and environmental degradation. There is a substantial shortfall in the availability of potable water in less developed countries, primarily arising from contamination and pollution. The fluoride contamination in drinking water is responsible for 65% of endemic flourosis in the world. Furthermore 50% of the groundwater sources in India have been contaminated by fluoride and more than 90% of rural drinking water supply programmes are based on ground water. The major sources of fluoride in groundwater are fluoride bearing rocks such as amphibole, biotite, fluorite and apatite. Fluoride is a common constituent of rocks, soils and waters with rock being the primary reservoir and ultimate source. The presence of fluoride in groundwater is governed by several factors like igneous rocks formation, magmatic processes. According to the Bureau of Indian Standard (BIS: 10500, 2010) the maximum tolerable limit of fluoride in groundwater is 1.5 ppm. Any dose of fluoride which is more than 1.5 ppm affects the human body by causing dental and skeletal fluorosis. The geochemical pathways of fluoride involve human populations of the tropics more directly than those of the temperate regions where food and water may be obtained from distant sources. Fluoride occurrence is very common in semi-arid climate with crystalline igneous rocks and alkaline soil.

Sources of Fluoride: The world's fluoride stores in the ground are assessed to 85 million tons. Out of which 12 million tons are situated in India. The most widely recognized fluoride-bearing minerals, which constitute normal hotspot for fluoride in drinking water, are fluorspar (CaF_2), rock phosphate, voracity & phosphorites.

The present study focuses on the geochemical analysis for fluoride in ground water and thematically represents it using Geographic Information System (GIS) for understanding of the present scenario at a glance. Here thematic map means particular theme connected with a specific geographic area. In the present study we have selected a Bagalkot and Hungund taluk around Malaprabha river basin, since the ground water in this area is contaminated with fluoride and other water chemical parameter. So we are interested to study the geochemical analysis of fluoride and the ion exchange process taking place in the ground water. Using the GIS software by interpreting the laboratory results of fluoride and other chemical parameter mapping can be done, so that we can easily analyze the variation of groundwater chemical parameter in the area. This study will help to know causes for fluoride generation in the groundwater and also keep the people aware about health effects of excess fluoride in the area.

Study Area: Bagalkot town is the district headquarters. The district is located in the northern part of the state of Karnataka. In the present study, the area is in and around Hungund Taluk and Bagalkot Taluk, Karnataka state, India. It is situated 50 km apart from the east of Bagalkot. The area falls in Survey of India top sheets 47 P/16, 56 D/4 covering an area of 664 Sq.km. It is bounded between latitude 16º 1' 11" - 16º 14' 1' N and 75º 48' 8"- 76º 5' 28'' E longitude. The area is a gently undulating to a plain terrain, dotted with isolated hills. The elevation ranges from around 525 m to 705 m almost sloping from west to east. The area falls in northern dry agro – climatic zone and experience semi arid climate. The main drainage of study area is Malaprabha River. The soil characteristic of study area shows sandy clay and the average rainfall of study area is 584 mm. Figure 1 shows the map of the study area.

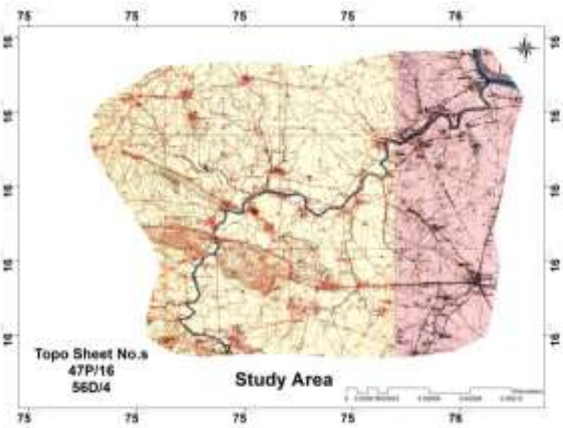


Fig 1 Study area

MATERIALS AND METHODOLOGY

Data collection: In this study we are selecting the bore well points at various places in the study area, to locate bore well point, latitude and longitudes are taken for GIS mapping purpose. The Ground water samples are collected and static ground water level is measured. Surface soil information around the bore well was collected; mean while geological formation of the area will be studied and collected the information. The water samples are analyzed for chemical parameters. In the study area four types of soils are observed Viz. Calcareous clay soil, Moderate black soil, Deep black soil, Alluvial soil.

Water Quality Analysis It is very important to know whether the water is fit for human utility or not and it can be determined by analyzing chemical properties of water. In the laboratory study water samples are analysed for six chemical parametres. The chemical parameters are: pH, Fluoride, Total hardness, Total dissolved solids, Chloride, Nitrate by the standard methods of sampling and test (physical and chemical) for water samples are adopted for analyzing the quality parameters.

Standards for Drinking Water Potable water must be suitable for maintaining human health. Water quality standards give a basis for selecting or rejecting water intended for human use. These standards provide minimum accepted values for safeguarding human health.

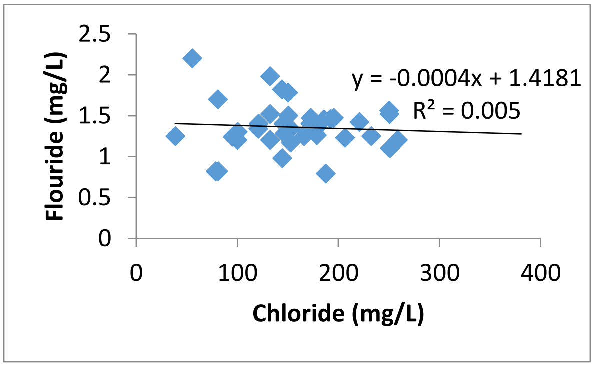
In Bagalkot and Hungund Taluk out of 42 samples 15 samples are non potable. Out of 15 samples, 8 samples are non potable due to Fluoride contents, 1 sample is non potable due to Total Dissolved Solids, and 6 samples are non potable due to Hardness.

RESULTS AND DISCUSSION

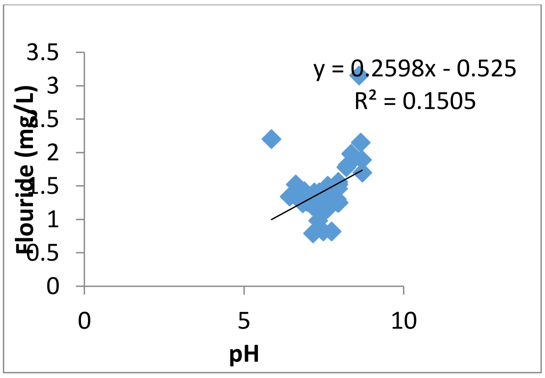
Results of various chemical parametrs within the study area were presented in the form of thematic maps generated using ARC GIS 10.1.

1) Fluoride: In the study area fluoride level of water varies from 0.79 and 3.15 mg/L and is in desirable limit i.e., 1.0 to1.5 as specified by the BIS. Figure 1.2 shows that spatial distribution of fluoride in the study area. Some villages like Kirsur, Hadalagi, Hiremalgavi and Chittawadgi have higher concentration of fluoride this may lead to diseases like dental fluorosis and skeletal fluorosis.
2) Chloride: According to BIS the permissible limit of chloride in drinking water is 250 mg/L. Figure 1.3 shows that spatial distribution of chloride in the study area and it is fluctuating in between 38.54 to 380.80 mg/L. High concentration of chloride was observed as 380.80 mg/L.
3) Total Dissolved Solids: According to BIS the desirable limit of TDS is 500 mg/L. If TDS value is more than 500 mg/L, it may cause gastro intestinal irritation. Figure 1.4 shows spatial distribution of TDS in the study area, which is fluctuating between 180 to 3952 mg/L.
4) Hardness: The limit of total hardness value for drinking water is to be within 300 mg/L of CaCO3. Figure 1.5 shows the spatial distribution of hardness. Spatial distribution of hardness in the study area and it is fluctuating in between 82 to 1702 mg/L.
5) pH: In the study area pH level of water varies from 5.86 and 7.96 and is in desirable limit i.e., 6.5 to 8.5 as specified by the BIS. Figure 1.6 shows that spatial distribution of pH in the study area
6) Nitrate: Figure 1.7 shows spatial distribution of nitrate in the study area and it is varying from 9.32 to 48.34 mg/L. The higher concentration of nitrate causes illness known as infant met hemoglobin.

Correlation study of fluoride with other chemical parameters: From the below graph it shows that fluoride is negatively correlated with chloride, since the fluoride is highly electro negative than chloride as the fluoride concentration increases chloride concentration decreases, due to the exchange of fluoride with chloride.



From the below graph it shows the fluoride and pH has fair positive correlation. Lower pH favors the adsorption of fluoride on the surface of clay. A higher value of pH favors the enrichment of fluoride in groundwater. Hence the increase in pH with the increase in fluoride content is observed.



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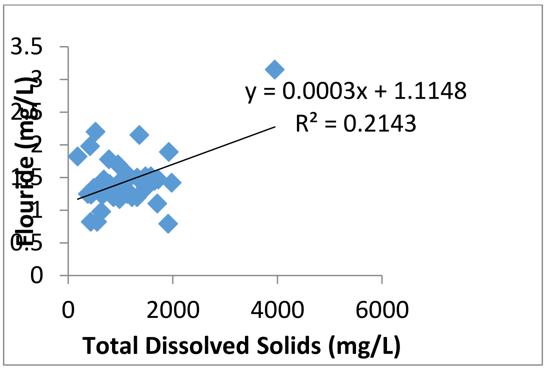
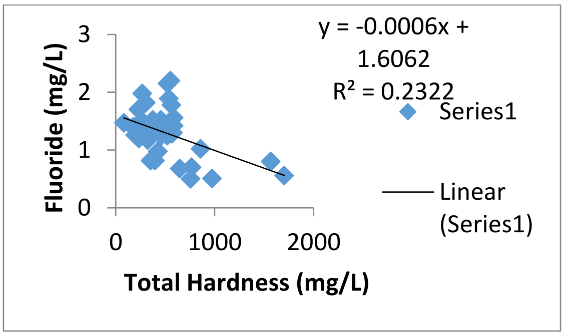
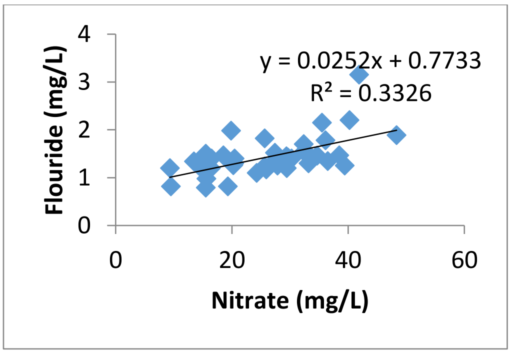
From the below graph it shows a positive correlation between fluoride and the total dissolved solids. Since a dissolved solid gives more opportunity for fluoride to be present and most of the metal fluoride are soluble



From the below graph it shows a negative correlation between fluoride and the total hardness. Hardness of water is mainly due to calcium salts in water .As hardness increases formation of calcium fluoride (CaF_2) an insoluble salt formation increases. Therefore decrease in fluoride content as the increase in hardness of water is observed.



From the below graph it shows a positive correlation between fluoride and the nitrate. Since nitrate is an oxidizing agent it increases the solubility of Fluoride in groundwater.



From below graph it may be contemplated that as the depth of the bore well increases the contact area and time increases. Hence it may be concluded that fluoride content increases with increase in depth of bore wells.

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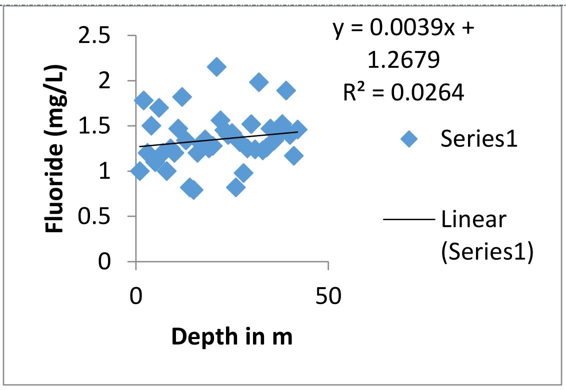

Ion exchange process:
Minerals containing fluoride present in the soil are in the form of complex salts which will undergo several chemical changes. During the process strong acid formation, strong base formations do occur in nature. This environment provides dissolution of fluoride in water in the form of NaF through a complex reaction involving H_4SiO_4 which will undergo neutralization with Na_2CO_3/ NaOH to give NaF, which will be present in the water. All these reactions taking place in accordance with chemical equilibrium.

$2HF + Na_2CO_3 \rightarrow 2NaF + CO_2 + H_2O$
$HF + NaHCO_3 \rightarrow NaF + H_2O + CO_2$

Fluoride present in the water as fluoride ion, due to the almost complete dissociation of the parent fluoride compounds. The solubility of CaF_2 that is present in the minerals increases with the increase in total alkalinity in the ground water according to the following reactions.

$CaF_2 + CO_3^{2-} \rightarrow CaCO_3 + 2F^-$
$CaF_2 + 2HCO_3^- \rightarrow CaCO_3 + 2F^- + H_2O + CO_2$

A higher value of pH favors the enrichment of F^- in groundwater. The OH^- in groundwater with high value of pH can replace the exchangeable F^- of fluoride containing minerals (muscovite) thus can increase the concentration of fluoride in groundwater. The hydroxyl ions replace F^- from muscovite as shown below.

$KAl_2[AlSi_3O_{10}]F_2 + 2OH^{-1} \rightarrow KAl_2[AlSi_3O_{10}[OH]_2 + 2F^-$

CONCLUSIONS
Fluoride concentration of ground water of some villages in the study area is found to be above the standard limits. Fluoride bearing minerals like feldspar, quartz, hornblende, plagioclase etc are found in the granite, gneiss, schist, shale, sandstone and conglomerate rock formations. These minerals in the sub surface provide a significant source of fluoride in groundwater. Ion–exchange within the study area and to some extent evaporation is the major contributing factors of fluoride contamination in the study area. Activity of the F ion is also highly unsaturated with respect to fluorite. Out of 42 bore wells studied 15 bore wells water is unfit for drinking purpose due to high content of various minerals, out of which 8 are due to high fluoride content. In the study area fluoride is high, with concentration ranging from 0.4 to 3.12 mg/L, 8 of the samples contained fluoride concentration that exceed the drinking water standard of 1.5 mg/L set by WHO.

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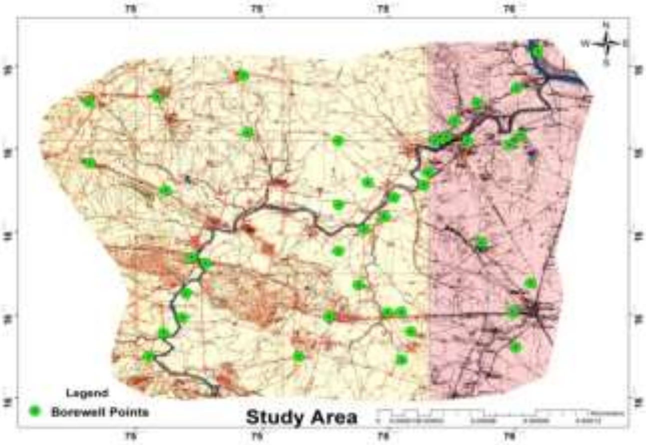

Fig 2 Delineated map of the study area

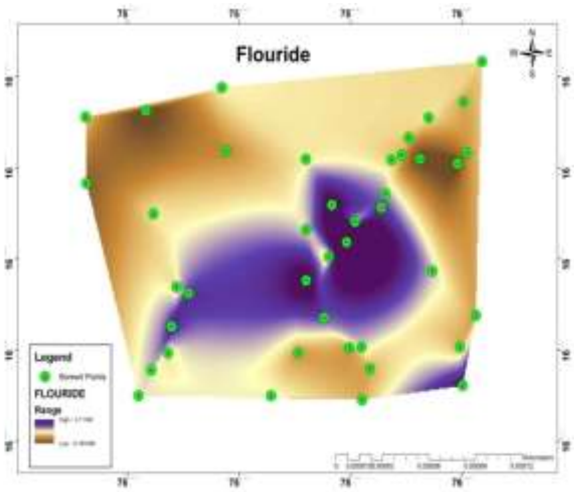

Fig 3 Interpolated Distance Weighted map of Fluoride

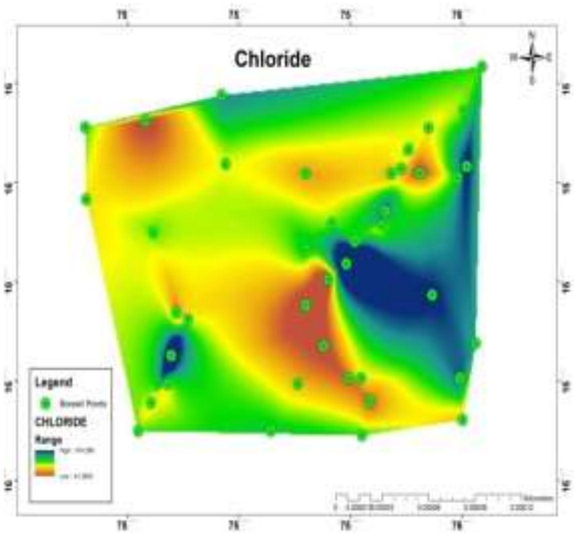

Fig 4 Interpolated Distance Weighted map of Chloride

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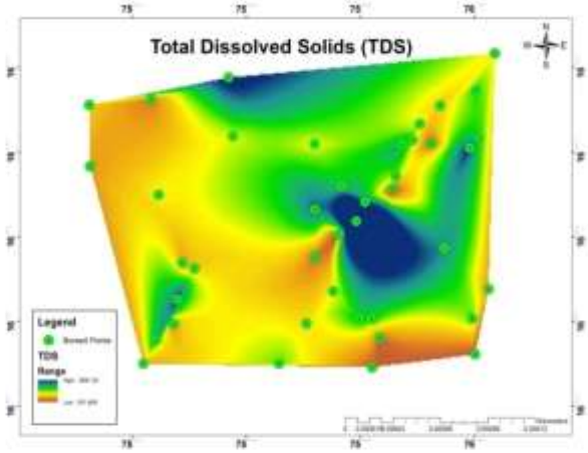

Fig 5 Interpolated Distance Weighted map of (TDS)

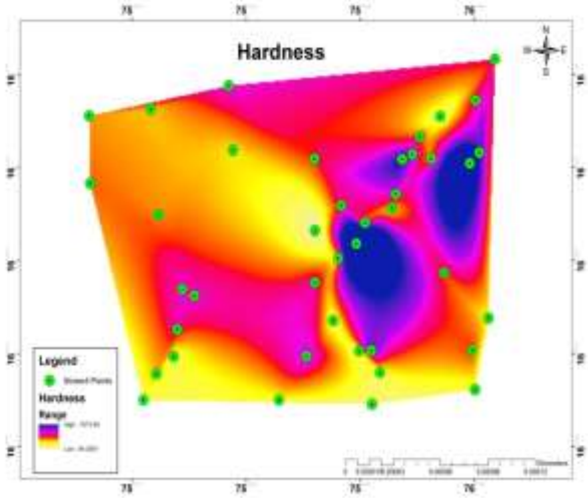

Fig 6 Interpolated Distance Weighted map of Hardness

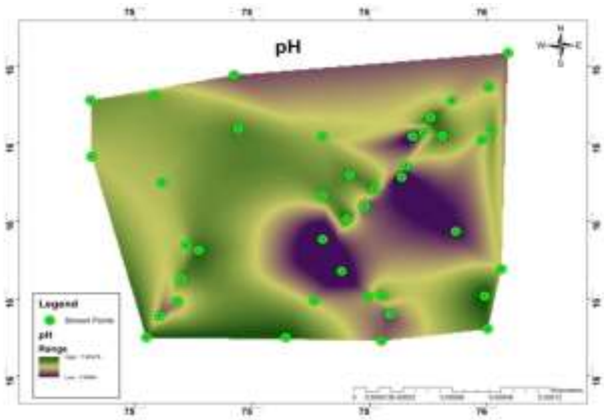

Fig 7 Interpolated Distance Weighted map of pH

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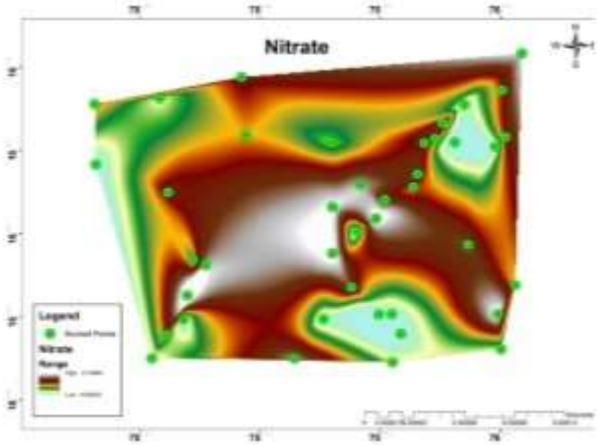

Fig 4.7 Interpolated Distance Weighted map of Nitrate

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