SPATIAL DISTRIBUTION OF IRON CONTENT IN THE AQUIFERS USING GIS INTERPOLATION AND TREATMENT USING LOW COST FILTER MEDIA: A CASE STUDY IN UDUPI TALUK

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Abstract— **Water is an essential resource for various beneficial uses. Surface water and groundwater is extensively used to meet the various domestic and industrial demands. Increased urbanization and industrialization are discharging the wastewater into the environment without treatment. By the runoff and infiltration, the water is reaching surface and subsurface water bodies and contaminating the fresh water. Treating groundwater is costly and requires proper assessment.**

The selected study area is Udupi Taluk of Karnataka state, where the water from the unconfined aquifer is used more than the surface water. The subsurface water usage is much widely done in the region like Udupi. The literature says that among the physio - chemical characteristics iron is very sensitive in the region like Udupi.

The lateritic soil in the region induces iron content to the water. Iron content in the water causes stains on the clothes, increases corrosive action of water, and leads to the growth of iron bacteria. According to the BIS 10500: 2012 the acceptable limit is 0.3mg/lt.

The higher concentration of iron in the region is may be due to point and non - point sources such as leakage from landfills, municipal sewers, septic tanks, infiltration of irrigation water containing pesticides and fertilizers, accidental spillage of paints and pigments, pollution from petrochemical and volatile organic compounds extensively used in industry, saltwater intrusion, etc. All these lead to major health effects and water-borne diseases.

Therefore, the study for the iron plays a major role in the area like Udupi. The groundwater quality parameter such as iron content from randomly chosen open wells is analyzed in the laboratory. The interpolation approaches are used to spatially distribute the iron content across the area. The maps generated gives the variation of iron content and also the vulnerable or the sensitive areas with respect to iron. The generation of maps using GIS application acts as a decision support system for the administrators to take up preventive measures to reduce the water pollution in the area. The area having sensitivity with respect to Iron as per the BIS 10500:2012 were treated using the technique of filtration. In this filtration process the low-cost filter media sugarcane bagasse ash is used to treat the water with the greater efficiency of in the range of 70% and which is within BIS Limit.

The project is relevant to society as water is basic necessity, this kind of maps and low-cost treatment will be having societal benefits. As the low-cost filter media can be used in each and every household, the project also comes under lab to land theme.

Keywords: Iron analysis; Arc GIS; low-cost filter media; interpolation

1. INTRODUCTION

Water is very precious natural resource required for domestic usage. The subsurface water usage is much widely done in the region like Udupi. The literature says that among the physio - chemical characteristics iron is very sensitive in the region like Udupi.

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The higher concentration of iron in the region is may be due to point and non - point sources such as leakage from landfills, municipal sewers, septic tanks, infiltration of irrigation water containing pesticides and fertilizers, accidental spillage of paints and pigments, pollution from petrochemical and volatile organic compounds extensively used in industry, saltwater intrusion, etc. Even geological features sometimes induce some major ions into groundwater. All these lead to major health effects and water-borne diseases.

Therefore, the study for the iron plays a major role in the area like Udupi. The groundwater quality parameter such as iron content from randomly chosen open wells is analyzed in the laboratory. The interpolation approaches are used to spatially distribute the iron content across the area. The maps generated gives the variation of iron content and also the vulnerable or the sensitive areas with respect to iron. The generation of maps using GIS application acts as a decision support system for the administrators to take up preventive measures to reduce the water pollution in the area. The area having sensitivity with respect to Iron as per the BIS 10500:2012 were treated using the technique of filtration. In this filtration process the low-cost filter media

sugarcane bagasse ash is used to treat the water with the greater efficiency and the range is within BIS Limit.

2. STUDY AREA

Udupi district lies along the west coast of peninsular India and the gigantic Western Ghats bifurcate the district periphery from the rest of the peninsula. The district is situated between 13°04′ –13°59′ N latitude and 74°35′ –75°12′ E longitude enfolding an area of 3575 km^2. The area is about 88 km long and around 80 km wide, adjoined in the north by Uttara Kannada district; in the east by Shivamogga and Chikamagalur districts; in the south by the Dakshina Kannada district and in the west by Arabian Sea. Udupi district has seven taluks, namely, Brahmavara, Byndoor, Hebri, Karkala, Kapu, Kundapura and Udupi.

Highest annual rainfall of about 4000 mm occurs over the Udupi district in Karnataka. Agriculture is the main occupation with more than 80% of the inhabitants depending on agriculture for their livelihood, wherein only 40% of the land is available for cultivation. Three types of soils, namely, the yellow loamy soil, the sandy soil covering the beaches and the red lateritic soil could be seen within the district. At few locations, the medium-textured sandy soil acts as a very good media for groundwater recharge. The region is occupied by rocks such as granitic gneisses with occasional laterite caps, and unconsolidated river and marine sediments. The gneiss, which varies widely in the separate outcrops, is present, particularly along the river courses. Basic intrusions such as dolerites, gabbros, and acid intrusives such as pegmatite, quartz veins and pink porphyritic granites are also observed throughout the district.

Udupi Taluk lies along the west coast of peninsular India and the gigantic Western Ghats bifurcate the district periphery from the rest of the peninsula. The taluk is situated between 13.3389° N latitude and 74.7451° E longitude enfolding an area of 68.23 km^2 figure 1. The area is about 55 km north of the educational, commercial and industrial hub of Mangalore and about 422 km west of state capital Bangalore by road. As per the census in 2011, Udupi city has 33,987 households and a total population of 144,960, The city population is growing at a rate of 14.03%. The major source of potable water for domestic usage is the groundwater of unconfined aquifer.

Udupi has an elevation of 27 m (89 ft) above mean sea level. The climate in Udupi is hot in summers and pleasant in winter. During summers (from March to May) the temperature reaches up to 38 °C (100 °F) and in winters (from December to February) it is usually between 32 and 20 °C (90 and 68 °F). As it is a coastal area, there are a few beaches which are tourist attractions. Kaup beach, Malpe beach are two of the beaches in Udupi.

Figure 1 Study Area – Udupi Taluk

3. METHODOLOGY

3.1 GROUND WATER

Groundwater is fresh water located in the subsurface pore space of soil and rocks. It is also water that is flowing within aquifers below the water table. Sometimes it is useful to make a distinction between groundwater that is closely associated with surface water, and deep groundwater in an aquifer called fossil water.

Groundwater is the water present beneath Earth's surface in rock and soil pore spaces and in the fractures of rock formations. About 30 percent of all readily available freshwater in the world is groundwater. A unit of rock or an unconsolidated deposit is called an aquifer when it can yield a usable quantity of water. The depth at which soil pore spaces or fractures and voids in rock become completely saturated with water is called the water table. Groundwater is recharged from the surface; it may discharge from the surface naturally at springs and seeps, and can form oases or wetlands. Groundwater is also often withdrawn for agricultural, municipal, and industrial use by constructing and operating extraction wells. The study of the distribution and movement of groundwater is hydrogeology, also called groundwater hydrology.

Typically, groundwater is thought of as water flowing through shallow aquifers, but, in the technical sense, it can also contain soil moisture, permafrost (frozen soil), immobile water in very low permeability bedrock, and deep geothermal or oil formation water. Groundwater is hypothesized to provide lubrication that can possibly influence the movement of faults. It is likely that much of Earth's subsurface contains some water, which may be mixed with other fluids in some instances.

Groundwater is often cheaper, more convenient and less vulnerable to pollution than surface water. Therefore, it is commonly used for public water supplies.
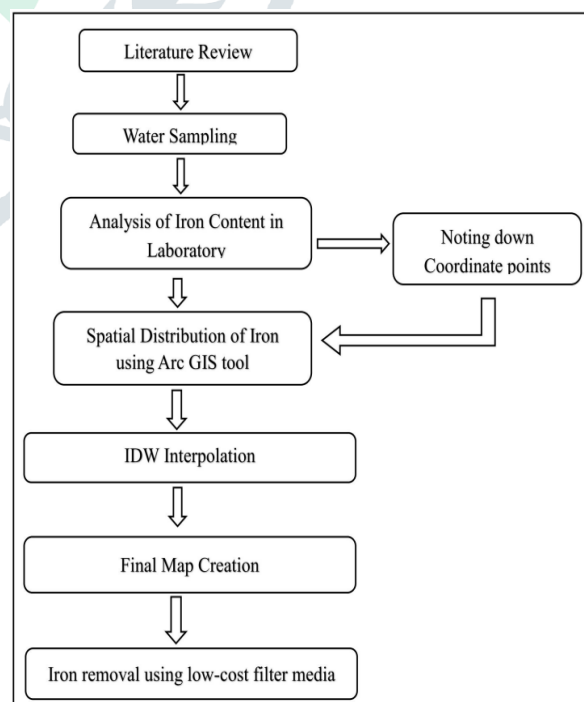

Figure 2 Methodology Flowchart

3.1.1 Groundwater sampling

Groundwater from wells were sampled and analysed according to the American Public Health Association standards of water sampling (APHA 2005). The sampling method adopted was 'grab sampling'. Water samples from 50 different wells located within the Udupi taluk and also water samples from10 different wells located outside Udupi taluk were collected during the pre-monsoon period of the year 2023. Bottles used for storing water samples were first carefully cleaned and then the groundwater samples were gathered. Groundwater sampling well locations plotted using location coordinates in the GIS environment. Each and every water samples were prudently preserved after collection and transferred to the chemical lab for testing. The groundwater samples so obtained were tested for iron. The obtained test results were compared with standard permissible values recommended by the Bureau of Indian Standards (BIS:10500 2012). Water quality parameters, method of analysis, their SI units for iron is 0.3 mg/l. The water quality parameters of iron evaluated in the laboratory using standard techniques according to the APHA 2005 guidelines.

3.1.2 Analysis of Iron content in the laboratory

Aim: To determine the amount of iron in the given sample by colorimetric method (using spectrophotometer)

Apparatus used:
- Spectrophotometer
- Glass cuvette
- Silica dish
- 1000,500,250,100 ml standard Borosil round flask
- Heating mantle
- Pipette
- Funnel

Reagents:
- Standard iron solution 0.01 mg iron per ml
- Concentrated HCL
- Hydroxyl amine solution
- Ammonium acetate buffer
- Sodium acetate buffer
- Phenanthroline solution

Procedure:
1. Pipette out 1ml, 2ml, 3ml……of standard iron solution into 100ml standard flasks.
2. Add 1ml hydroxylamine and 1ml sodium acetate buffer to each standard flask.
3. Dilute the solution in the standard flasks to 75 ml with distilled water.
4. Then add 5ml of Phenanthroline monohydrate solution to each flask and make up to 100ml with distilled water.
5. Take 25ml or 50ml of water sample in a 250ml beaker.
6. Add 2ml of concentrated hydrochloric acid and 1ml hydroxylamine solution to this and boil for 10minutes, cool and transfer this solution to a 100ml standard flask.
7. Add 10ml ammonium acetate and 5ml Phenanthroline monohydrate and make up to the mark with distilled water.
8. Wait for 10minutes and then match the colour obtained for the water sample with the standard colours prepared.
9. Find the weight of iron in the standard flask with which a match is obtained with the standard flask which contains water sample.

10. Prepare standard graph by taking absorbance value of each standard using spectrophotometer using concentration of iron on x axis and absorbance on y axis.
11. Find out the absorbance value of sample and plot on standard graph to find out the concentration of iron in sample

3.2 GEOGRAPHIC INFORMATION SYSTEM (GIS)

A geographic information system (GIS) consists of integrated computer hardware and software that store, manage, analyse, edit, output, and visualize geographic data. Much of this often happens within a spatial database, however, this is not essential to meet the definition of a GIS. In a broader sense, one may consider such a system also to include human users and support staff, procedures and workflows, the body of knowledge of relevant concepts and methods, and institutional organizations.

Geographic information systems are utilized in multiple technologies, processes, techniques and methods. They are attached to various operations and numerous applications, that relate to: engineering, planning, management, transport/logistics, insurance, telecommunications, and business. For this reason, GIS and location intelligence applications are at the foundation of location-enabled services, which rely on geographic analysis and visualization.

GIS provides the capability to relate previously unrelated information, through the use of location as the "key index variable". Locations and extents that are found in the Earth's spacetime are able to be recorded through the date and time of occurrence, along with x, y, and z coordinates; representing, longitude (x), latitude (y), and elevation (z). All Earth-based, spatial–temporal, location and extent references should be relatable to one another, and ultimately, to a "real" physical location or extent. This key characteristic of GIS has begun to open new avenues of scientific inquiry and studies. The application of GIS technology has made the evaluation of environmental, geological and natural resources, including groundwater resources, much simpler. GIS is widely used in geological studies for the identification of mine resources, site suitability analyses, determination of groundwater vulnerability zones to contamination, managing site inventory data, and integrating groundwater quality assessment models to create spatial decision support systems with the help of spatial data. GIS improves the groundwater quality interpretation and the geostatistical methods are reliable and precise in predicting the spatial variability of the groundwater quality data.

3.2.1 Geostatistical Modelling

The ArcGIS Geostatistical Analyst Extension software set was used for spatial interpolation. Spatial interpolation is a robust technique for exploring the spatial distribution and patterns of point and areal data. This technique integrates or harness the spatial correlation within the data of known variables. Interpolation techniques are based on the hypothesis that the values nearer to each other are more similar than those which are farther. Gauged values are used to predict at any ungauged locations.

There exist several interpolation methods available in ArcGIS software. In the current study, a deterministic interpolation approach, i.e., the inverse distance weightage (IDW) method, and a geostatistical interpolation approach, i.e., the ordinary kriging method were implemented on the data collected from 60 sampling locations. The best performing technique of

interpolation was identified with the use of cross-validation procedure.

❖ *Inverse distance weightage method (IDW):*

The IDW technique is a flexible optimal interpolation method wherein a linear combination of values is used by which unknown values are interpolated and calculated at the required points. The IDW interpolation generates expected value at each point on the basis of the weighted average of the nearest sample points. The neighbourhood size decides what number of spatially distributed points are involved in IDW, wherein weights are attributed to the point location where the value is to be estimated. This weight is dependent on the distances between the measured and unknown points. The power is applied on the basis of the power of 10. Less power distributes the weights among the neighbourhood points more evenly. The weights are characteristic of the range between the sampled and unsampled points for i = 1, 2, ..., n in IDW technique. The interpolation scheme is represented in the following equation

$$K = \frac{\sum_{i=1}^{n} \frac{1}{(D_i)^a} \cdot k_i}{\frac{1}{(D_i)^a}}$$

where K represents the interpolated value at the point of interest; ki denotes the rate of sampling location, i = 1, 2, ..., n; Di is the distance between the sampled and unsampled locations and a indicates a constant factor, which receives the value of 1 or 2.

❖ *Kriging:*

Kriging works based on the existence of spatial autocorrelation among the sampled points; the sampling points on the neighbourhood are more similar than those which are far apart. Ordinary Kriging (OK) is the best known and most commonly used method of interpolation used in geostatistical modelling. The experimental variogram analyses the average extent of difference between the unsampled location and a neighbouring sampled location value and the autocorrelation is being depicted based on varying distances. Weighted least squares and dependency ratio parameters (e.g. range, nugget and sill) are calibrated to obtain an appropriate model (e.g., circular, spherical and exponential) that forms the experimental variogram. The inclusion of interdependency of variables and the accessible error surface output are some of the benefits of this technique. The ordinary kriging interpolation uses the relationship as mentioned below

$$K = \sum_{i=1}^{n} \emptyset_i \, K\,(x_i)$$

where K defines the predicted value; K(x$_i$) is the sampled value at x$_i$; i is the unknown weight for the sampled value at the ith location and n is the integer used in the identified locations of the region.

The ratio of the nugget to sill which is expressed in percentages was considered as a criterion for determining the spatial dependence of groundwater quality parameters in the kriging technique of interpolation. This ratio is called the dependency ratio. If this proportion is > 25%, it indicates the strong spatial dependence of the variable; if the ratio is between 25 and 75%, it indicates the variable has moderate spatial dependences and if it exceeds 75%, it portrays weak spatial dependence.

❖ *Model verification: Semi-variogram models:*

The semi-variogram models (circular, spherical, Penta spherical, exponential, Gaussian, rational quadratic, K-Bessel hole, J-Bessel, and stable) were evaluated for each information set. Based on cross-validation performance, the best fit model for the particular parameter was identified. Semi-variance values were calculated for each of the data sets using SAS procedure. Variogram models were fitted based on the visual evaluation. The nugget, partial sill and spatial correlation range were included in the parameters.

The range of semi-variogram indicates a spatial scale or distance beyond which data samples become spatially uncorrelated, the nugget indicates small-scale spatially uncorrelated variation in the data, and sill denotes the degree of constant variance amid uncorrelated samples in the data. Practical range relates to the scope of spatial correlation. For each parameter of the dataset, semi-variograms were established. For assessing the efficiency of estimates of semi-variogram models, the statistical indices such as R^2, RMSE and dependency ratio values were calculated and evaluated. This defines the adequacy with which the semi-variogram model described the spatial variability.

The cross-validation procedure was used to test and establish the suitable kriging semi-variogram model which provides the best interpolation (predicted values). Verification of the model is very much necessary to understand how well the parameters are coherent with the performance. Optimal prediction maps via interpolation were obtained by cross-validation. The Root Mean Square Error (RMSE) under the category of error statistic verifies the preciseness of predictions. The coefficient of determination (R^2) statistic was also determined for comparison of the model efficiencies. The calculation of RMSE is as follows

$$RMSE = \sqrt{\sum_{i=1}^{n} (K_i - P_i)^2 \big/ n}$$

where n is the number of sampling points, K$_i$ is the measured value, and P$_i$ is the predicted value.

$$Dependency\ ratio\ (\%) = \frac{Nugget}{Sill\ (Nugget+Patial\ sill)} * 100$$

3.3 FILTRATION:

Filtration is a process that removes particles from suspension in water. Removal takes place by a number of mechanisms that include straining, flocculation, sedimentation and surface capture. Filters can be categorised by the main method of capture, i.e. exclusion of particles at the surface of the filter media i.e. straining, or deposition within the media i.e. in-depth filtration.

Strainers generally consist of a simple thin physical barrier made from metal or plastic. In water treatment they tend to be used at the inlet to the treatment system to exclude large objects (e.g. leaves, fish, and coarse detritus). These may be manually or mechanically scraped bar screens. The spacing between the bars ranges from 1 to 10 cm. Intake screens can have much smaller spacing created by closely spaced plates or even fine metal fabric. The latter are usually intended to remove fine silt and especially algae and are referred to as micro strainers.

Filters, as commonly understood in water treatment generally consist of a medium within which it is intended most of the particles in the water will be captured. Such filters might be manufactured as disposable cartridge filters, which can be suitable for domestic (i.e. point-of-use treatment) and small-scale industrial applications. Larger forms of cartridge filters

exist which can be cleaned. One version is precoat filtration in which a porous support surface is given a sacrificial coating of diatomaceous earth, or other suitable material, each time the filter has been cleaned. Additionally, a small amount of the diatomaceous earth is applied continuously during filtration. However, in most cases, filters used in municipal water treatment contain sand or another appropriate granular material (e.g. anthracite, crushed glass or other ceramic material, or another relatively inert mineral) as the filter medium. Filtration using such filters is often referred to as in-depth granular media filtration.

Granular media filters are used in either of two distinct ways which are commonly called slow-sand filtration and rapid gravity or pressure filtration. When the filters are used as the final means of particle removal from the water, then the filters may need to be preceded by another stage of solid-liquid separation (clarification) such as sedimentation (Sedimentation Processes), dissolved-air flotation (Flotation Processes) or possibly a preliminary stage of filtration.

Other processes take place in vessels similar to those used for granular media filtration, and in some respects the processes do have similarities with filtration but filtration is not their sole or primary purpose. Therefore, such processes are not considered further in this article. Examples include vessels filled with granular activated carbon for removal of dissolved organic substances, and vessels filled with ion exchange resin for removal of inorganic and organic ions. There are applications of filters that whilst filtration (removal of particles) does take place a secondary process is intended to also occur, e.g. iron and manganese removal, and arsenic removal.

3.3.1   Filter Media used:

- The filter media is made up of simple glass with chambers, one for the materials and one for the filtered water to get stored.
- The filter media used for the analysis include the materials like fine sand, charcoal, rice husk ash, coconut coir, sugarcane bagasse ash.
- The total height of the glass filter media is 40cm. Length* Breadth = 40cm*20cm
- A tap is provided at the bottom end of the unit to act as an outlet for filtered water.
- Each layer of the filter media materials are of 4cm.

3.3.2   Filter media materials:

- *Rice Husk Ash*:

Combustion of rice hulls affords rice husk ash (acronym RHA). This ash is a potential source of amorphous reactive silica, which has a variety of applications in materials science. Most of the ash is used in the production of Portland cement. When burnt completely, the ash can have a Blaine number of as much as 3,600 compared to the Blaine number of cement (between 2,800 and 3,000), meaning it is finer than cement. Silica is the basic component of sand, which is used with cement for plastering and concreting. This fine silica will provide a very compact concrete. The ash also is a very good thermal insulation material. The fineness of the ash also makes it a very good candidate for sealing fine cracks in civil structures, where it can penetrate deeper than the conventional cement sand mixture.

A number of possible uses for RHA include absorbents for oils and chemicals, soil ameliorants, a source of silicon, insulation powder in steel mills, as repellents in the form of "vinegar-tar" release agent in the ceramics industry, as an insulation material. More specialized applications include the use of this material as a catalyst support.

- Coconut coir:

In agriculture and horticulture, coir is a substitute for sphagnum (peat moss) and peat because it is widely available and environmentally friendly. Many sources of coir however are heavily contaminated with pathogenic fungi, and the choice of the source is important. Coir is also useful to deter snails from delicate plantings, and as a growing medium in intensive glasshouse (greenhouse) horticulture. Coconut coir from Mexico has been found to contain large numbers of colonies of the beneficial fungus Aspergillus terries, which acts as a biological control against plant pathogenic fungi.

Coir is also used as a substrate to grow mushrooms. The coir is usually mixed with vermiculite and pasteurised with boiling water. After the coir/vermiculite mix has cooled to room temperature, it is placed in a larger container, usually a plastic box. Previously prepared spawn jars are then added, spawn is usually grown in jars using substrates such as rye grains or wild bird seed. This spawn is the mushrooms mycelium and will colonize the coir/vermiculite mix eventually fruiting mushrooms. Coir is an allergen, as well as the latex and other materials used frequently in the treatment of coir. Coir can be used as a terrarium substrate for reptiles or arachnids.

Coir fibre pith or coir dust can hold large quantities of water, just like a sponge. It is used as a replacement for traditional peat in soil mixtures, or, as a soil-less substrate for plant cultivation. It has been called "coco peat" because it is to fresh coco fibre somewhat like what peat is to peat moss, although it is not true peat.

Coir waste from coir fibre industries is washed, heat-treated, screened and graded before being processed into coco peat products of various granularity and denseness, which are then used for horticultural and agricultural applications and as industrial absorbent. Usually shipped in the form of compressed bales, briquettes, slabs or discs, the end user usually expands and aerates the compressed coco peat by the addition of water. A single kilogramme of dry coco peat will expand to 15 litres of moist coco peat.

Coco peat is used as a soil conditioner. Due to low levels of nutrients in its composition, coco peat is usually not the sole component in the medium used to grow plants. When plants are grown exclusively in coco peat, it is important to add nutrients according to the specific plants' needs. Coco peat from Philippines, Sri Lanka and India contains several macro- and micro-plant nutrients, including

substantial quantities of potassium. This extra potassium can interfere with magnesium availability. Adding extra magnesium through the addition of magnesium sulphates can correct this issue.

Some coco peat is not fully decomposed when it arrives and will use up available nitrogen as it does so (known as drawdown), competing with the plant if there is not enough. This is called nitrogen robbery; it can cause nitrogen deficiency in the plants.

Poorly sourced coco fibre can have excess salts in it and needs washing (check electrical conductivity of run-off water, flush if high). It holds water well and holds around 1000 times more air than soil. Adding slow release fertilizers or organic fertilizers are highly advised when growing with coco fibre.

- Charcoal:

Charcoal may be activated to increase its effectiveness as a filter. Activated charcoal readily adsorbs a wide range of organic compounds dissolved or suspended in gases and liquids. In certain industrial processes, such as the purification of Sucrose from cane sugar, impurities cause an undesirable color, which can be removed with activated charcoal. It is also used to absorb odors and toxins in gases, such as air. Charcoal filters are also used in some types of gas masks. The medical use of activated charcoal is mainly the absorption of poisons. Activated charcoal is available without a prescription, so it is used for a variety of health-related applications. For example, it is often used to reduce discomfort and embarrassment due to excessive gas (flatulence) in the digestive tract.

Animal charcoal or bone black is the carbonaceous residue obtained by the dry distillation of bones. It contains only about 10% carbon, the remainder being calcium and magnesium phosphates (80% and other inorganic material originally present in the bones. It is generally manufactured from the residues obtained in the glue and gelatin industries. Its decolorizing power was applied in 1812 by Derosne to the clarification of the syrups obtained in sugar refining, but its use in this direction has now greatly diminished, owing to the introduction of more active and easily managed reagents. It is still used to some extent in laboratory practice. The decolorizing power is not permanent, becoming lost after using for some time; it may be revived, however, by washing and reheating.

- Sand:

All of these methods are used extensively in the water industry throughout the world. The first three in the list above require the use of flocculant chemicals to work effectively. Slow sand filters produce high-quality water without the use of chemical aids.

Passing flocculated water through a rapid gravity sand filter strains out the floc and the particles trapped within it reducing numbers of bacteria and removing most of the solids. The medium of the filter is sand of varying grades. Where taste and odor may be a problem (organoleptic impacts), the sand filter may include a layer of activated carbon to remove such taste and odour.

Sand filters become clogged with floc or bio clogged after a period in use and they are then backwashed or pressure washed to remove the floc. This backwash water is run into settling tanks so that the floc can settle out and it is then disposed of as waste material. The supernatant water is then run back into the treatment process or disposed of as a waste-water stream. In some countries, the sludge may be used as a soil conditioner. Inadequate filter maintenance has been the cause of occasional drinking water contamination
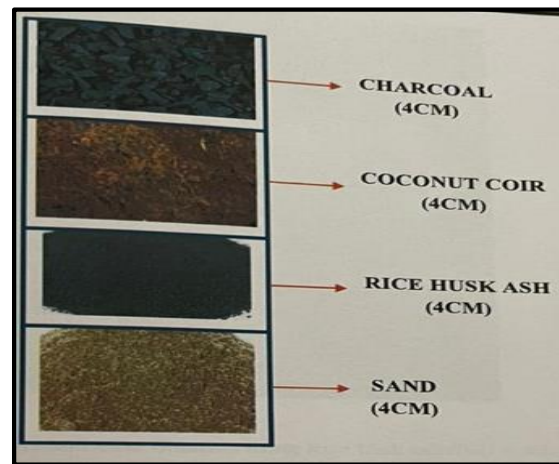

figure 3 Mixed Layers of Filter Media

3.3.3　Filtration Process:

In the proposed design of the model, the initial characteristic of the sample was determined by conducting iron test. The concentration of iron in the preparation of iron water sample was determined and it was passed through the open end of unit. Inside the glass filter, filtration media of specified thickness (5cm and 15cm) were placed.

Sample water was made to pass through the top end of the unit. After filtration, the clear water was collected through the outlet of the unit in a beaker and the final concentration of iron was measured using spectrophotometer. The rate of filtration was noted and for each filtration media, for analysing filter effectiveness of technique.

4.　RESULTS AND DISCUSSIONS
4.1 IRON CONCENTRATION DETERMINATION:

Pure water has no taste, but water is a natural solvent. Most minerals from groundwater, including iron, will be filtered by water. Large amounts of iron in drinking water can give it an unpleasant metallic taste. Iron is an essential element in human nutrition, and the health effects of iron in drinking water may include warding of fatigue and anaemia. The thing that you'll notice the most from water that is high in iron is that the water may taste metallic. The water may be discoloured and appear brownish, and it may even contain sediment. Iron content in the water causes stains on the clothes, increases corrosive action of water, and leads to the growth of iron bacteria. Iron content varied between 0 and 6.55 mg/l and the acceptable limit is 0.3 mg/l. This may be due to the presence of higher iron content in the lateritic soil.

Table 4.1 Standard Absorbance Values of Iron

Flask no.	Volume of std. solution (ml)	Conc. of std. Iron (100ml)	Conc. of std. Iron (1000mg/lt)	Absorbance value
1	1	0.01	0.1	0.017
2	2	0.02	0.2	0.030
3	3	0.03	0.3	0.034
4	4	0.04	0.4	0.048
5	5	0.05	0.5	0.061
6	6	0.06	0.6	0.071

4.1.1   Details about the Iron Content in Udupi:

Total of 50 samples were collected in Udupi Taluk and the test is taken as mentioned in chapter 3.1.1. The values are shown n table 4.2. The graph is plotted for concentration of iron (mg/lt) v/s absorbance value as shown in fig 4.1. From the graph, the observation made is that the Iron in 5 locations exceed 0.3 mg/lt and 45 are within the range. The 5 locations which exceed 0.3mg/lt are Dendoorkatte (0.655 mg/lt), Ambalpady (0.48 mg/lt), Bailoor (0.325 mg/lt), Kuthpady (0.44 mg/lt), Santekatte (0.305 mg/lt). Iron content in the water causes stains on the clothes, increases corrosive action of water, and leads to the growth of iron bacteria. Iron content varied between 0 and 6.55 mg/l and the acceptable limit is 0.3 mg/l. This may be due to the presence of higher iron content in the lateritic soil. Hence the water must be treated well before drinking filtration.

4.2 SPATIALLY DISTRIBUTE THE IRON CONTENT USING ARC GIS.

The inverse distance weightage (IDW) method of interpolation was used. Here the statistical indices, namely, the R^2 and RMSE are used to evaluate the accuracy of spatial interpolation. The IDW technique is a flexible optimal interpolation method wherein a linear combination of values is used by which unknown values are interpolated and calculated at the required points. The IDW interpolation generates expected value at each point on the basis of the weighted average of the nearest sample points. The neighbourhood size decides what number of spatially distributed points are involved in IDW, wherein weights are attributed to the point location where the value is to be estimated. This weight is dependent on the distances between the measured and unknown points.

From figure 4.5 the iron concentration in Udupi taluk is exceeding 15 to 20% in some areas and in major part of the taluk the iron content is in the range of 0.15 to 0.3 mg/lt. The blue colour in the map shows the areas are safe and have the required quantity of iron. The areas which have more Iron must be treated well and filtration method can be used.
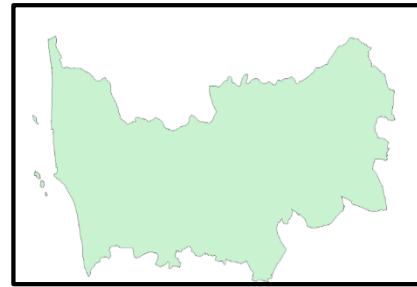

Figure 4.2 Shape file of Udupi Taluk
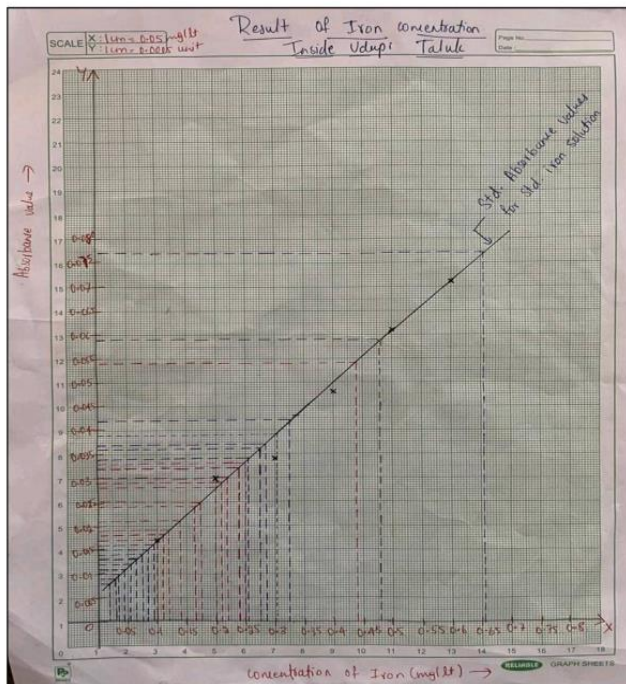

figure 4.3 Coordinates of sampling Locations

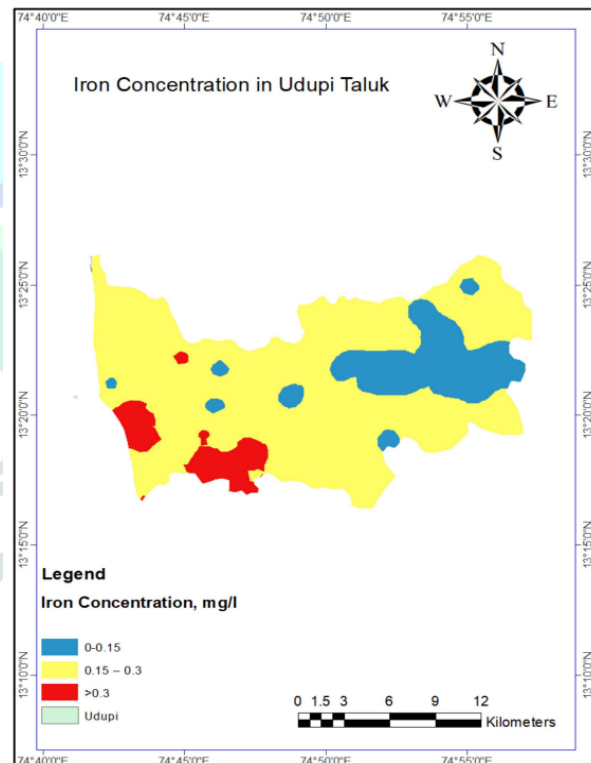figure 4.4 Interpolation map of iron concentrations

Figure 4.1 Result of iron concentration in Udupi Taluk
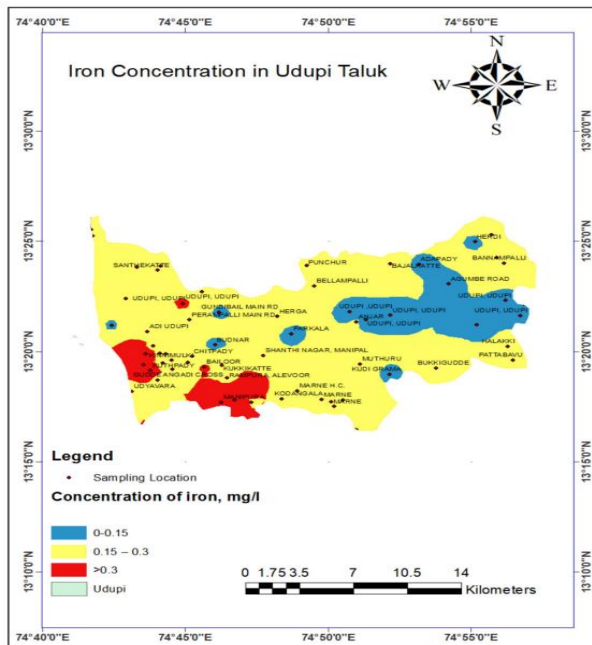
Fig 4.5 Final Interpolation map of Iron concentrations with sample locations

Table 4.2 Iron Values in Udupi Taluk

SL.NO.	PLACE	LATITUDE	LONGITUDE	CONC. OF IRON (mg/l)
1	PARKALA	13.346	74.812	0.110
2	UDDINAHITHLU, BADANIDIYOOR	13.373	74.715	0.200
3	BUDNAR	13.338	74.767	0.110
4	TA PAI ROAD, AMBALPADI	13.331	74.727	0.480
5	ANJAR	13.355	74.850	0.165
6	SHANTHI NAGAR, MANIPAL	13.3301	74.795	0.175
7	BAILOOR	13.321	74.761	0.325
8	BHIMANAGAR, BAILOOR	13.325	74.751	0.065
9	CHITPADY	13.329	74.754	0.085
10	VEIGAS TOWNSHIP, KINNIMULKI	13.319	74.742	0.055
11	KINNIMULKI	13.324	74.736	0.100
12	AMBALPADY TEMPLE PREMISES	13.337	74.731	0.045
13	ADIUDUPI	13.348	74.728	0.240
14	KUTHPADY	13.323	74.725	0.075
15	KUKKIKATTE	13.322	74.771	0.095
16	GUDDE ANGADI CROSS	13.311	74.734	0.085
17	KUTHPADY	13.318	74.729	0.440
18	KODAVOOR, MALPE	13.353	74.707	0.095
19	MARNE	13.295	74.835	0.275
20	NAYARKERE ROAD, BRAHMAGIRI	13.331	74.738	0.100
21	KODANGALA	13.297	74.806	0.120
22	MARNE H.C.	13.303	74.815	0.110
23	GUNDUPADE, MOODUBELLE	13.291	74.837	0.255
24	KINNIMULKI	13.326	74.742	0.075
25	RAMPURA, ALEVOOR	13.313	74.774	0.055
26	PERNANKILA	13.296	74.842	0.165
27	KAPPETTU GARADI ROAD	13.331	74.735	0.140
28	UDYAVARA	13.303	74.719	0.035
29	MOODU ALEVOOR	13.294	74.788	0.140
30	MARNE	13.296	74.829	0.250
31	MANIPURA	13.294	74.770	0.285
32	DENDOORKATTE	13.296	74.778	0.655
33	UDUPI, UDUPI	13.357	74.855	0.095
34	UDUPI, UDUPI	13.363	74.846	0.055
35	AGUMBE ROAD	13.384	74.903	0.120
36	HIRYADKA AJJEKAR ROAD	13.353	74.920	0.030
37	UDUPI, UDUPI	13.360	74.945	0.020
38	UDUPI, UDUPI	13.371	74.937	0.085
39	UDUPI, UDUPI	13.360	74.869	0.095
40	UDUPI, UDUPI	13.397	74.721	0.095
41	KALYANPURA MAIN RD	13.397965	74.735736	0.220
42	UDUPI, UDUPI	13.369624	74.748833	0.325
43	UDUPI, UDUPI	13.378392	74.759832	0.210
44	GUNDIBAIL MAIN RD	13.363161	74.769695	0.075
45	PERAMPALLI	13.357	74.752	0.220
46	SANTHEKATTE	13.394	74.733	0.305
47	VANTIYALA	13.421	74.928	0.240
48	BUKKIGUDDE	13.320	74.896	0.210
49	PADETU HOUSE	13.274	74.85	0.175
50	MUTHURU	13.323	74.852	0.220

4.3 FILTRATION

As mentioned in chapter 3.3 the iron samples which are above 0.3mg/lt are filtered in the filter media. Two samples were taken for filtration, which are from Dendoorkatte and Ambalpadi. About 5ltr of water samples were filtered in the filter media. Dendoorkatte sample was recorded 0.665mg/lt before filtration, 0.43mg/lt after single filtration and 0.18mg/lt after double filtration. Ambalpadi sample was recorded 0.49mg/lt before filtration and 0.275mg/lt after single filtration. After filtration of both samples the iron concentration range was within the limit and also the filtration efficiency.

Filtration is the simplest and cheapest technique for iron removal. As per this study, among individual it has been noted that rice husk ash (89.4%) gives better results with increase in 15cm depth. The iron content of sample decreases, one of pros of using rice husk ash is that it gives visibly clear water without imparting any colour to water. The increase in dosage of adsorbent upto some extent can increase efficiency of adsorption. It is observed that cost of sugar cane bagasse, charcoal, coconut coir, rice husk ash as filter material was economical. These filter media are chemical free too. Both rice husk and Charcoal can be easily procured. Mixed media layer which is the combination of Sand, Coconut coir, Rice husk ash and Charcoal.

Hence mixed media layer is economical and is used for iron removal. Totally this is environmental friendly project. The project is relevant to society as water is basic necessity, this kind of maps and low cost treatment will be having societal benefits. As the low cost filter media can be used in each and every household, the project also comes under lab to land the theme.

Figure 4.6 Filtration Media and its process

Figure 4.7 Results of Filtration Process

5. CONCLUSION

- The Iron analysis conducted in the laboratory shows few samples above 0.3 mg/l which is above the BIS 10500, 2012 permissible limit. The categorization of the study area into 3 zones such as safe, better, danger.

- Interpolation methods such as deterministic and geostatistical approaches help to determine the water quality status at any unsampled areas using the values of the sampled locations using IDW.

- Water quality mapping using GIS tool proves to be the most illuminate method for identifying the areas that come under various water quality categories. Mapping of water quality index clearly depicts the areas that need critical policy measures for the sustainable utilization of groundwater resources.

- This study acts as a decision support system for taking up water quality management activities for groundwater remediation in the study area.

- Filtration is the simplest and cheapest technique for iron removal. Hence mixed media layer is economical and is used for iron removal. Totally this is environmental friendly project.
- The project is relevant to society as water is basic necessity, this kind of maps and low cost treatment will be having societal benefits. As the low cost filter media can be used in each and every household, the project also comes under lab to land theme.

6. SCOPE FOR FUTURE WORK

- Instead of iron other parameters of water can also be tested such as pH, turbidity, chlorine analysis, fluorine analysis, nitrogen analysis, etc.
- Other Interpolation methods can also be used and comparison can be done.
- Other treatment methods using Low-cost filter media can be done.

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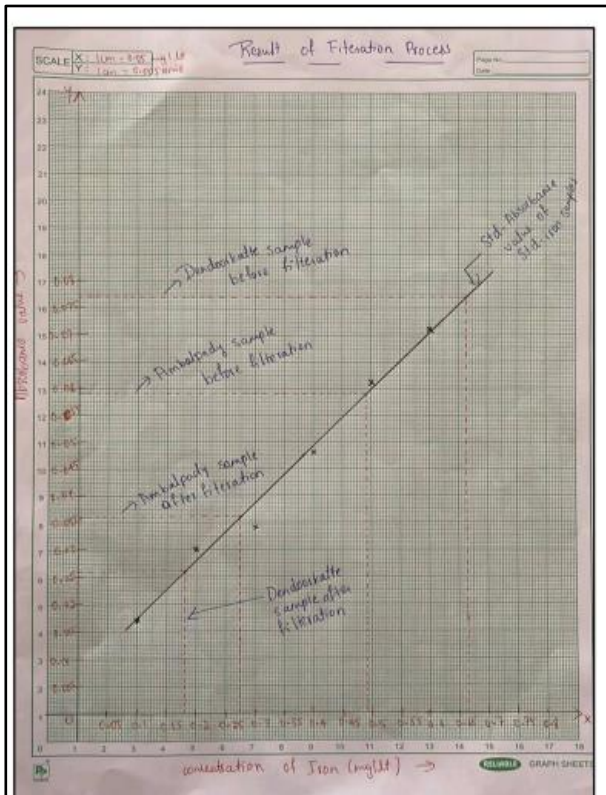Asadi, (2020) "Assessment of groundwater quality in west metropolitan of Iran: An application of GIS and modeling". Environ Qual Manage;1–14

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