Assessment of Ground Water Pollution Potential Zones for Contract Farming Using Remote Sensing and G.I.S

(A Case Study for Anekal Taluk, Bangalore Urban District, Karnataka).

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Abstract:- **Contract farming is a well-established concept in developed nations. Although relatively new in India, it is rapidly gaining popularity and is being increasingly practiced across the country. Contract farming offers a revolutionary business model which addresses key concerns of the industries as well as farmers and provides substantial benefits to both, without compromising interest of the other.**

Anekal taluk is geographically located between E 12^0 39' 30" to 12^0 56' 30" North latitude and N 77^0 32' 30" to 77^{0}50' East Longitude. The Taluk measures 512 sq.km. Anekal taluk represents an uneven landscape with intermingling of hills and valleys. The ground is much dissected and is a region of rapid erosion.

Contract farming has resulted in intensive agriculture in few parts of semi urban areas where farmers use intensive fertilizer and pesticides. This agricultural non-point source pollution is leading to source of water quality impact. Nitrogen from fertilizers, manure waste and ammonia turns into nitrite and nitrates. High level of this toxins enter ground water and end up in drinking water. Ammonia, pesticides as well as oil, degreasing agents metals and other toxins from farm equipments pollute the ground water. Preventing ground water contamination is particularly important because ground water once contaminated is very difficult and expensive to clean up. Hence the need for Assessment of Ground water pollution potential zones is essential. DRASTIC Index Methodology, which is an empirical assessment methodology, helps in the identification of pollution potential zones for contract farming. DRASTIC index uses a set of seven hydrogeological key parameters to classify the vulnerability or pollution potential of an aquifer. The parameters viz., Depth to groundwater D, recharge due to rainfall R, aquifer media A, Soil media S, topography T, impact of vadose Zone I, and hydraulic conductivity C, are weighted with respect to their relative importance to the pollution potential.

All DRASTIC parameters layers in spatial formats are put into G.I.S. (Gypsy Software available with Pegasus software company, Bangalore).

The layers were assigned weights and ratings (for the range of values of the parameters) and the combined inter actively in the computer system. The DRASTIC INDEX MAP or pollution potential map was generated on a minute grid. The water quality parameters measured at different sites in Anekal Taluk is compared with water quality standards and Drastic index. Six categories of vulnerability to ground water pollution were characterized.

The Drastic Index represents a relative measure of ground water pollution potential. Ground water pollution potential or relative vulnerability assessment helps farmers, planners and administrators in broadly screening areas for contract farming. DRASTIC type of site evaluation helps in evaluating alternatives for directing the financial resources and land use activities to the appropriate areas.

Key Words : Ground Water, Drastic, Pollution Potential, Recharge, Soil Media, Topo graphy, Vadose Zone, Hydraulic Conductivity

INTRODUCTION

The Importance of water for sustaining human, animal and plant life needs no emphasis. Human health and welfare, agricultural growth, industrial development and Eco balance are all at critical stage, unless water and land resources are managed more efficiently now than in the past. Even today more than 90% of our rural population is primarily dependent on groundwater. So, it is essential to conserve groundwater in quantity as well as quality.

Agriculture impacts heavily on water use and thus ultimately upon water quality. Agricultural production processes generate residuals which can be grouped into six major categories: soil sediments, nutrients, pesticides, mineral salts, heavy metals, and disease organisms. The purpose of this study is to provide a frame work for environmental management and its relation to agricultural activities, to achieve a good practical guide specifically with water resources to the farmers and agricultural administrators.

A strategy for the protection of groundwater must be aimed at protecting aquifers from becoming contaminated. Preventive efforts should be directed first at land use activities that pose a higher risk of causing pollution from both point and non-point sources. Care must be exercised to avoid groundwater development that leads to the degradation of quality or depletion of supplies. Regulatory and technological measures must cover all categories of point and non-point sources. Domestic sewage, municipal and industrial landfills, mining operations and agricultural practices, overexploitation of aquifers leading to quality degradation must be prevented.

A unique study has been made for Anekal taluk, one of the three taluks of Bangalore Urban District. It is Alarming to note that the quality of water has deteriorated and aquifers are recharged with low quality water. The pollution potential of the study area is assessed by DRASTIC methodology, wherein hydrogeological setting is given more importance, besides, each one in the acronym representing a parameter.

STUDY AREA

Anekal taluk is geographically located between 12^0 39' 30" to 12^0 56' 30" North latitude and 77^0 32' 30" to $77^0$50' East Longitude. The Taluk measures 512 sq.km. Anekal taluk represents an uneven landscape with intermingling of hills and valleys. The ground is much dissected and is a region of rapid erosion. The eastern portion of the taluk is a plain country. The western portion of the taluk is jungly and marked by continuous hills. The weather is neither very humid nor dry. The annual average precipitation over the taluk is about 890 mm.

Anekal taluk has a typical hydrogeologic setting. The entire taluk comprise of mainly granetic gneiss belonging to precambrian age. The granetic gneiss is exposed as a continuous chain of mounds raising from 300 to 500 feet above the ground level.

The depth of weathering is gentle. The central and eastern portions of taluk show maximum thickness of weathered mantle.

The population mainly depend on agriculture for their subsistence. The farming is mainly dry one as taluk has not got any major rivers big stress. Irrigation is mainly carried out by means of water from tanks and wells. The principal dry crops are ragi and cereals. The wet crops are paddy, sugarcane. In addition to the other crops, areca, coconut, grapes, banana, ground nut, vegetables etc., are also grown to some extent. Mulbary cultivation is also seen here and there.

OBJECTIVES

The main objective of this investigation is to identify pollution potential areas for contract farming in the study area. This pollution potential areas act as the screening tool to assess the vulnerability to groundwater pollution. The study is also to prioritize the areas, to prevent further contamination of groundwater due to contract farming.

MATERIAL AND METHODS

DRASTIC is a groundwater pollution vulnerability assessment spatial deterministic model.

DRASTIC uses a set of seven hydrogeologic key parameters to classify the vulnerability or pollution potential of an aquifer. The parameters are assigned weights with respect to their relative importance to the pollution potential of the aquifer. The DRASTIC parameters are

- Depth to ground water (D)
- Recharge due to rainfall (R)
- Acquifer media (A)
- Soil media (S)
- Topography (T)
- Impact of Vadose Zone (I)
- Conductivity (C)

DRASTIC INDEX (DI) = $D_rD_W+R_RR_W+ A_RA_W+ S_RS_W+T_RT_W+I_RI_W+C_R\, C_W$,in which Refers to rating of the parameter ranges and W refers to the weighting of the parameter. Rating varies from 1 to 10 and are intended to reflect the relative significance of classes within each factor.

Depth to water is an important primary data which determines the depth of material through which a contaminant travels before reaching the aquifer. The published reports of Department of Mines and Geology GoK are used for finding depth to water in the study area. Recharge is defined as the total quantity of water which is applied on the ground surface.

Recharged water is the principal vehicle for leaching and transporting solid and liquid contaminants to the water table. The rainfall data of six rain gauge stations with sixteen years of observations have been used. The recharge value polygons are obtained using revised norms of groundwater estimation committee report. Aquifer media refers to the consolidated or unconsolidated rock which serves as a storage of water. In the preparation of polygonal unit of aquifer media satellite remote sensing derived hydrogeomorphological maps and geological maps are used. The soil map from NBLUSS Centre, Bangalore was enlarged to 1:50,000 scale. The soil units represented on maps are suitably combined into various textural unit polygons representing varied ability of contaminant to move vertically into the vadose zone. Topography refers to the slope and slope variability of the land surface. The slope map is derived using SoI topo sheets. The Impact of vadose zone is a complex phenomena combining aquifer media and topographic characteristics. Hydraulic conductivity refers to the ability of the acquifer material to transmit water. The hydraulic conductivity values are calculated after computing transmissivity from pumping test data.

The weightages are assigned using, US EPA (works of Aller et al.,) for all the DRASTIC parameters. Suitable modifications are done in assigning ranges depending on the parameter values in the hydrogeologic setting for Anekal taluk.

RESULTS AND DISCUSSION

DRASTIC parameter layers were put as polygon coverages. The G.I.S approach provides the decision makers, a powerful tool for collecting, storing, retrieving, analyzing and displaying the parameter layers of data. Then assigning weightages for DRASTIC parameter values in the accompanying text files in done. Finally the ranges of each DRASTIC parameter is multiplied with weights and a layer by layer addition resulted in a final number called Drastic Index. Drastic Indiex ranges ranged from less than 110 as first category up to seventh category which is having DRASTIC Index greater than 160. Thus pollution potential map with minute grid is then obtained.

The water quality parameters namely PH, TDS, EC, HCO_3, Cl, SO_4, Ca, Mg, Na, and SAR values for twenty two locations in Anekal taluk are assessed in the laboratory. The water quality assessment is made for monsoon and non-monsoon seasons. They are compared with the standard values. The Drastic Indices ranges are further classified as very high, high, moderate, low, and very low for ground water vulnerability.

TA 1 Relative Vulnerability to groundwater pollution :

I. Drastic Index	Vulnerability
< 110	Veryless
> 110 <or = 120	Less
> 120 <or = 130	Moderate
> 130 <or = 140	Moderately high
> 140 <or = 150	High
> 150 <or = 160	Very High

TABLE – 2

Spearman's correlation co-efficient to measure the degree of relation between Drastic Indicies and water quality parameters:

Water quality parameters	Spearman's Rank Corelation coefficient.
Total dissolved solids	0.8838
Chlorine	0.8520
Magnesium	0.8823
Calcium	0.8367
Electrical conductivity	0.880
Bicorbonate hardness	0.9014

"DRASTIC INDEX MAP" or "POLLUTION POTENTIAL MAP" prepared using G.I.S in compared with the manually prepared pollution potential map. The results show that the variation between D.I. Map prepared using G.I.S and D.I. Map prepared manually is quite negligible.

Assuming non-linearity between Drastic Indices and water quality parameters, Spearman's rank correlation co-efficient is calculated (Table 2). The Spearman rank correlation co-efficient lying between 0.85 – 0.90 show that water quality parameters and Drastic indices are positively correlated.

The pollution potential map or (D.I. Map) so prepared helps in classifying areas into different vulnerability classes and classification helps in identifying the areas and villages which are more vulnerable to groundwater pollution.

CONCLUSIONS

The following conclusions can be drawn :

- The Drastic methodology adopted for preparing pollution potential map can be used as a screening tool to ascertain whether the area is more or less vulnerable to groundwater pollution to undertake contract farming.
- Drastic methodology may be used for pollution preventative purposes through prioritization of areas where groundwater quality protection is critical. The system may also be used to identify areas where special protection efforts are warranted. The moderately, highly and very highly vulnerable areas identified in Anekal taluk for groundwater pollution helps planners and administrators to undertake some precautionary measures, and to conduct detailed study against groundwater pollution.

- The pollution potential map prepared by using Drastic methodology helps in prioritization of areas for monitoring purposes. In the present study area a denser monitoring system might be installed in moderately, highly and very highly vulnerable areas of pollution potential zones for contract farming.

- The efficient allocation of resources for clean-up and restoration efforts after contamination has occurred is another possible use of "Drastic Index Map" or "Pollution Potential Map".

- Drastic index map or pollution potential map prepared manually and computer assisted (G.I.S) Drastic index map yield comparable results. (This is done based on minute grid D.I. index comparison).

- The pollution potential map thus prepared for Anekal Taluk helps the planners in broadly screening areas for contract farming sites, waste disposal sites, industrial sites etc.,

- The Drastic methodology also helps users to recommend the most hydro geologically acceptable setting for municipal and waste disposal sites and also helps users to direct resources for further evaluation.

- When the state or local administrators have limited resources available to devote to groundwater protection, they are forced to focus these resources in certain areas. The pollution potential map helps identify areas which are more or less vulnerable than others to contamination. This delineation allows administrators to direct their resources to those vulnerable areas most critical to groundwater contamination, thereby making use of most of the limited resources available.

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