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SPATIAL ANALYSIS ON DRINKING WELL WATER QUALITY IN ERAVUR PATTU DIVISIONAL SECRETARIAT, BATTICALOA, SRI LANKA

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ABSTRACT

Ground water is the only source for irrigation, drinking and domestic purposes in Batticaloa District. This study focused on the characterization of an independent aquifer in three selected GN divisions namely Koduwamadu, Pankudaweli and Veppaweduwan in EravurPattu DS division for its suitability for drinking. Groundwater samples were collected from wells to represent public and individual wells including dug and tube wells in the period of November 2013 to May 2014. Important parameters namely pH, EC and total dissolved solids were determined in water samples from 60 wells, while 15 wells were further studied for chemical parameters such as nitrite, nitrate and phosphate. Attribute information of the result was entered into a GIS database and analyzed through Geo statistical analysis tool and displayed on maps to show concentration levels at each site using Interpolation method via Kriging techniques. Significant spatial variations were observed in the maps where it exceeds the permissible limit in some locations. The intrusion of lagoon water, intensive agricultural use and depth of well are some of the influencing factors for the spatial variation of parameters. Continuous monitoring and quality assessment in well water are necessary to avoid possible health hazards to the people in the area.

INTRODUCTION

Water is one of the most essential natural resources for the life and it is a very important component for the development of country especially in maintaining the sustainability of the environment (Rajkumar, 2012). The rapidly increasing population and high human intervention create several environmental degradations including groundwater quality degradation (Ramesh Pandian, 2013). The groundwater contamination can be due to prevailing drought-prone conditions, improperly treated and unplanned release of effluents of industry, municipal and domestic into the nearby streams and ponds and the high usage of groundwater for irrigation which increase the ionic concentration of the groundwater and making it more saline. Coastal aquifers constitute an important source of fresh water supply but are often confronted with the problem of seawater intrusion (Nimalsanjayan and Rajendram, 2010) which makes the groundwater as a scarce resource. Moreover, groundwater contamination by pesticides and nitrates is an important epidemiological factor associated with the induction of various forms of cancer, reproductive and developmental toxicity and methemoglobinaemia (Horriganet *al*., 2002; Fewtrell, 2004; Avalanja and Bonner, 2005). Hence monitoring of groundwater quality has become vital in nature. Water quality is a major issue in Sri Lanka. Many communities obtain their drinking water from aquifers. Water suppliers drill wells through soil and rock into aquifers to reach the ground and supply the public with drinking water. Many homes also have their own private wells drilled on their property to tap this supply. Unfortunately, the ground water can become contaminated by human activity. These chemicals can enter the soil and rock, polluting the aquifer and eventually the well. Pollution and waste dumping contaminate water supplies leading to serious health impacts for nearby water users. Contaminants that may be present in untreated water include microorganisms, inorganic contaminants, organic and chemical contaminants from industrial processes, pesticides, herbicides and also radioactive contaminants. Water quality also depends on the local geology and ecosystem, as well as

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human practices such as sewage dispersion, industrial pollution, use of water bodies and overuse. Ground water is the only source for irrigation, drinking and domestic purposes in Batticaloa District. The Independence Aquifer which underlies these geographical areas provides groundwater for these purposes. The families of these villages use individual and common wells - constructed a long time ago by governmental and non–governmental organizations. It caused the over exploitation of groundwater which led to negative impact on both quantity and quality of water availability (Jeyakumar*et al*., 2002). Recent reports of government and non- governmental organizations state that the rate of depletion of this aquifer is increasing and not sustainable, and also report that the quality of this aquifer water does not meet acceptable drinking water standards, in particular locations (RIWASH, project, World vision, Lanka 2012). Findings of previous community studies show that people in these villages suspect the quality of the drinking water and avoiding using water from some common wells for drinking purposes.The present study was carried out to find the quality of drinking water in the public and domestic wells in the means of physical and chemical parameters in the selected GN divisions (Koduwamadu, Pankudaweli and Veppaweduwan), Batticaloa District, Sri Lanka. GIS has been applied to visualize the spatial distribution of groundwater quality in the study area. Geographical Information System (GIS) is used for the spatial analysis and it is a powerful tool for representation and analysis of spatial information related to water resources (Rangarajan*et al*., 2009).

MATERIALS AND METHODS

Description of the study area

The study was carried out in selected three GramaNiladari (GN) divisions (Koduwamadu, Pankudaweli, and Veppavettuwan) of EravurPattu District Secretariat (DS) Division, Batticaloa. The study area lies in the interior part of Batticaloa district in the Eastern Province which is belonged to the flat terrain comprising of lagoon, shrubs, forests, isolated hill rocks and streams. The study area is surrounded by the land mass and lagoon in one side. The study area is shown in the Figure 1.

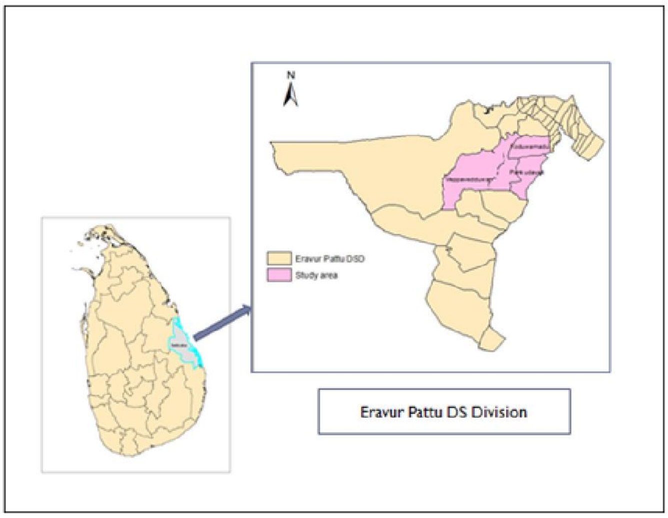

Fig.1. Location Map of Study Area

The study area is chiefly composed of non- calcic brown and alluvial soils along the border of lagoon (Dassanayake and De silva, 2010). The average annual rainfall of this zone varies between 1500 – 2000 mm contributed by the North-East monsoon which is the major component of recharging the aquifer. The mean annual temperature is 28-30°C. Evaporation is greater during the months of June, July and August showing the significance of high temperature and radiation. The major agricultural activities are paddy, annual field and vegetable crops and chena in shrub jungle (De Silva and Dharmasena, 2010). Around 7500 of the population live in these GN divisions (Statistical data, 2011) and depend upon groundwater for drinking and irrigation needs.

Collection of samples

The groundwater samples were collected from randomly selected 60 wells including dug and tube wells and tested for pH, electrical conductivity and total dissolved solids, while 15 wells were further studied for nitrite, nitrate and phosphate to identify the water quality. The water samples were collected in the period of November 2013 to May 2014. Samples were collected using direct bottle method (Tandon, 1998) and subjected to the analysis in the laboratory of the National Water Supply and Drainage Board (NWS&DB), Batticaloa within 48 hours after collection. Samples were analyzed for pH, Electrical Conductivity (EC), Total dissolved solids (TDS), Nitrite, Nitrate and Phosphate concentrations.

Data collection

Data collection was carried out to obtain rainfall, temperature, demographic details from Meteorological department, Batticaloa and Divisional Secretariat, EravurPattu DS Division, respectively. Field visits and observations were made during the sample collection and interviews were carried out from the households to gather socio-economic information, land use pattern and other water related informations in the study area.

Data analysis and Mapping

The collected data and quality parameters were analyzed in the SPSS package and MS excel to produce graphs and relevant charts. The software ArcGIS 9.2 was used for surface analysis based on the water quality results. Attribute information of the result were entered into a GIS database and analyzed through Geo statistical analysis tool in GIS technique, display on maps to show concentration levels at each site using Interpolation method via Kriging techniques.

RESULTS AND DISCUSSION

Sample locations

The spatial and attributes were generated using GIS to create spatial variation maps of water quality parameters such as pH, EC, TDS, Nitrite, Nitrate and Phosphate. The sample locations were obtained by the handheld GPS (Garmin Model) and they were uploaded into ArcGIS 9.2 to create the location map of the study area (Fig. 2).

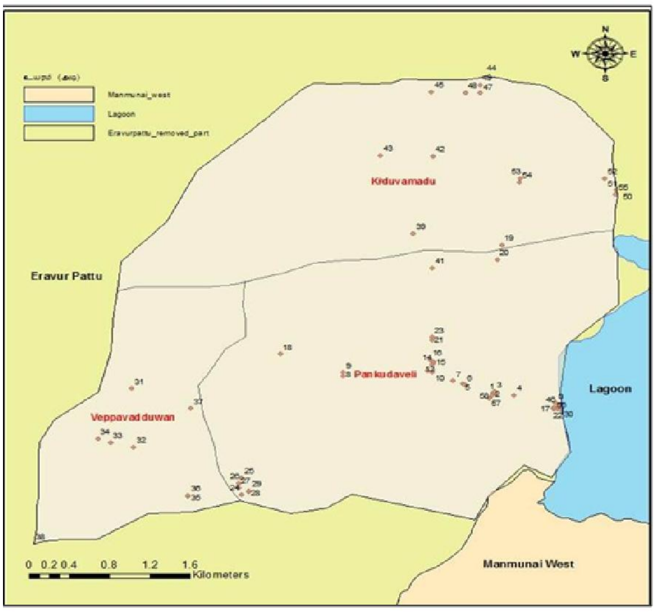

Fig.2. Location of selected wells in the Study Area

pH

The pH results from the water quality samples ranged from 6.17 to 8.64, where the SLS 614 (1983) indicates the desirable level should be between 7 and 8.5. pH is one of the most important parameters in drinking water and determines the acidic and alkaline nature of water (Ramesh Pandian, 2013). Figure 3 shows the spatial trend of the pH, where it represents the acidic nature along with the lagoon and the alkali in the interior part of the study area. The findings of the Ecosystem foundation (2006) also shows that pH determines by the solubility and biological activity of chemical constituent of nutrients such as nitrate and phosphate and the higher pH influenced by the bedrock geology, physiographic region and agricultural pollutants.

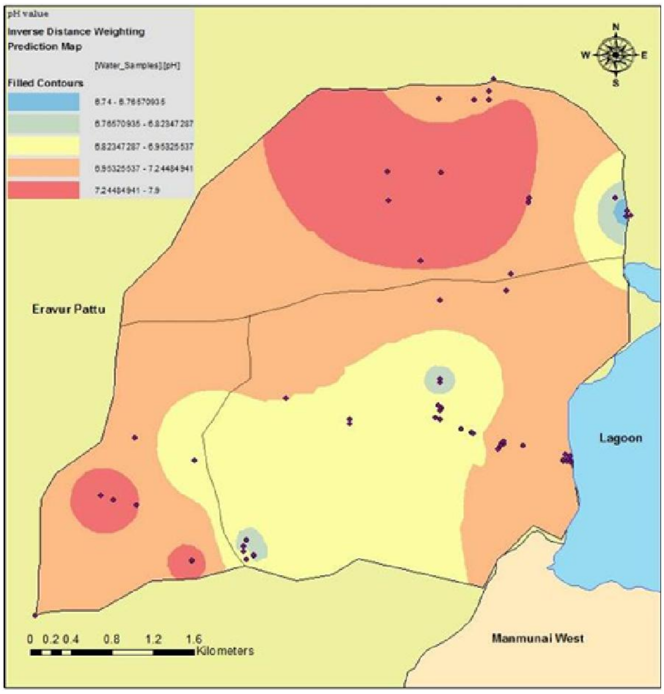

Fig.3. Spatial Variation Map of pH

Ec

The EC is a good indicator of the total salinity and also directly related to the concentration of ionized substances in water. The results of EC obtained from the samples varies between 150 to 6000 µs/cm which are below and above the desirable (750 µs/cm) and permissible (3500 µs/cm), respectively. The higher EC content was observed in the wells along the coastal area of lagoon (Fig. 4). Similar results were observed in the study of Jeyakumar*et al*., (2002) where the domestic wells in Vantarumoolai and Kaluthawalai areas in the Batticaloa District showed such variations of EC due to seasonal variation and sea water intrusion. The lagoon water intrusion in the study area may be the causal agent in creating the salinity hazard in the study area.

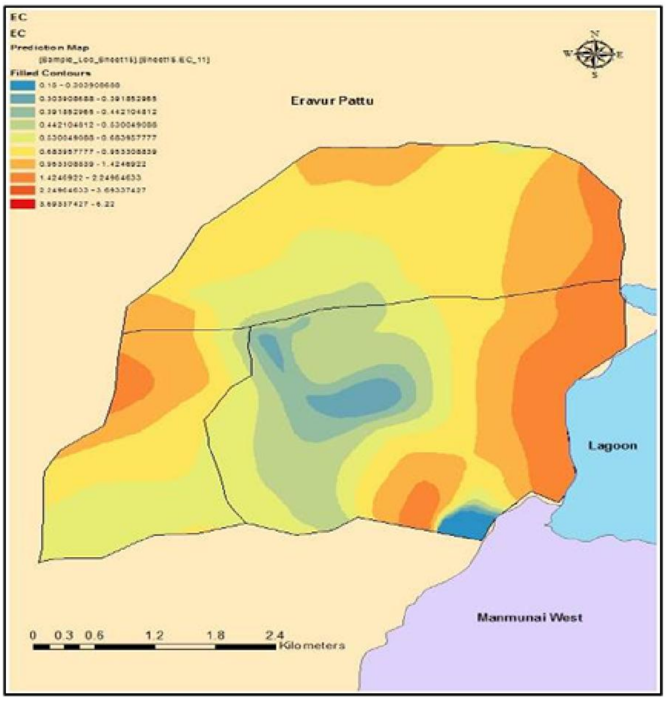

Fig.4. Spatial Variation Map of EC

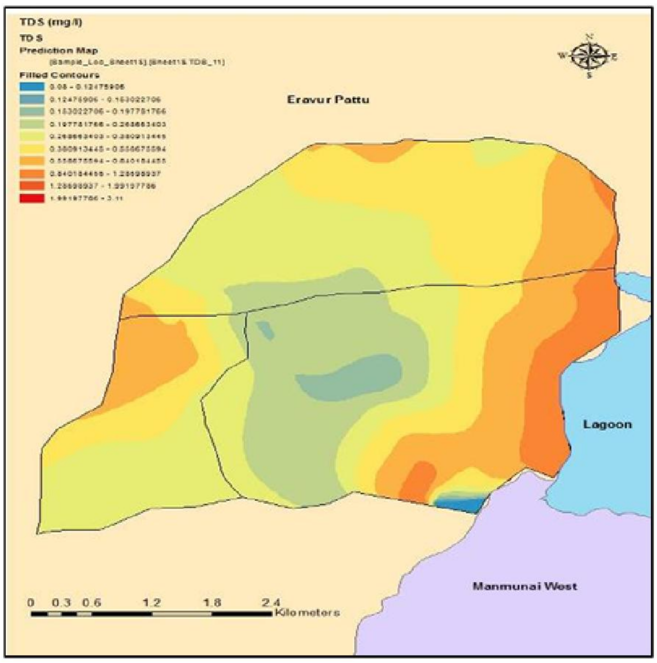

Fig.5. Spatial Variation Map of TDS

TDS

TDS gives the general nature of groundwater quality and extent of contamination in terms of residue dissolved ions (Udayalaxmi*et al*., 2010). It was found that the TDS in the well samples ranged from 80-3110 mg/l where it exceeds the permissible limit 1000 mg/l in some points. The highest concentrations were observed in the wells along with the coastal area of lagoon, where the EC is higher than in the interior part of the study area. The spatial variation map is shown in Figure 5. The study by Rajkumar (2012) shows the high level of TDS is associated with sedimentation, mining and storm water runoff.

Nitrite and Nitrate

The nitrite-N concentration was ranging from 0.01-0.385 mg/l and nitrate – N concentration was ranging from 0.3-18.4 mg/l where it exceeds the SLS 614 (1983) permissible limit of 0.1 and 10.0 mg/l, respectively. The spatial variation of nitrite and nitrate has been shown in Figure 6. Both parameters represent an increasing trend from the coastal part of lagoon to the interior part of the study area. Most of the paddy lands in this study area lie in the interior part. High intensive agricultural practices are being carried out in those areas during *Maha* and *Yala*. The wells situated adjacent to the paddy lands show higher concentration of nitrite and nitrate. Similar findings were obtained in the study of Thushyanthy and Shanthi de silva (2007) where the higher nitrate concentrations were observed in the wells used for agricultural purposes. Similar results were obtained from the studies of Kuruppuarachi*et al*., (1990), showed that the nitrate concentration in groundwater in dug wells exceeded the limit in the agricultural lands at Kalpitiya in Regosols and Vaheesan (2011) showed that the highest nitrate content was observed at Manmunai, Batticaloa as 96.60 mg/dm^3.

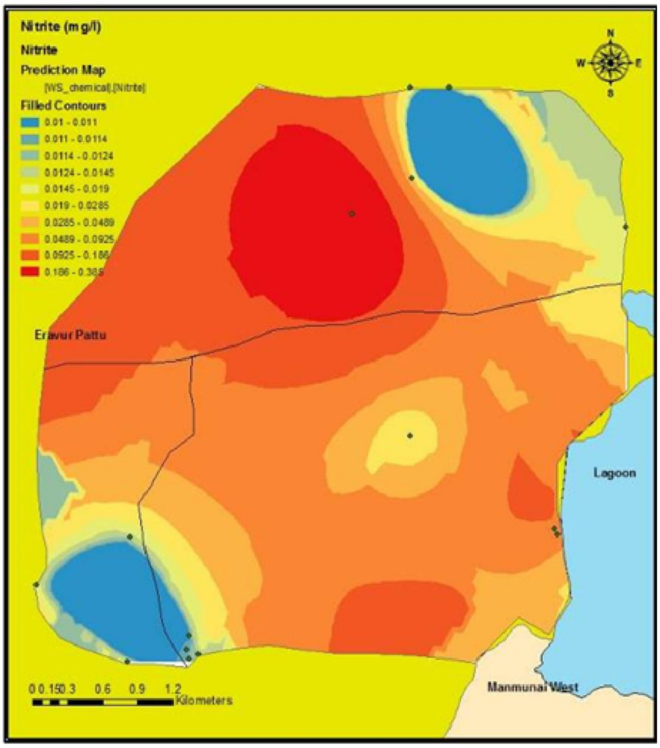

Fig.6 (a). Spatial Variation Map of Nitrite

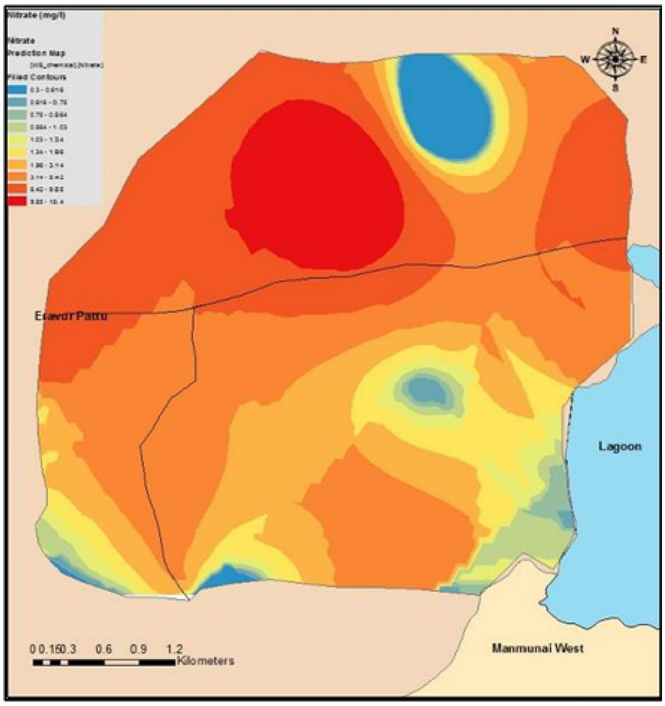

Fig.6 (b).Spatial Variation Map of Nitrate

Phosphate

Phosphate concentrations of the samples ranged from 0.04 to 2.5 mg/l where some of the well samples highly exceeds the permissible limit of the phosphate as 2 mg/l. the spatial variation shows that the higher concentration of the phosphate lie in the interior part of the study area where contains of the paddy lands (Fig.7).

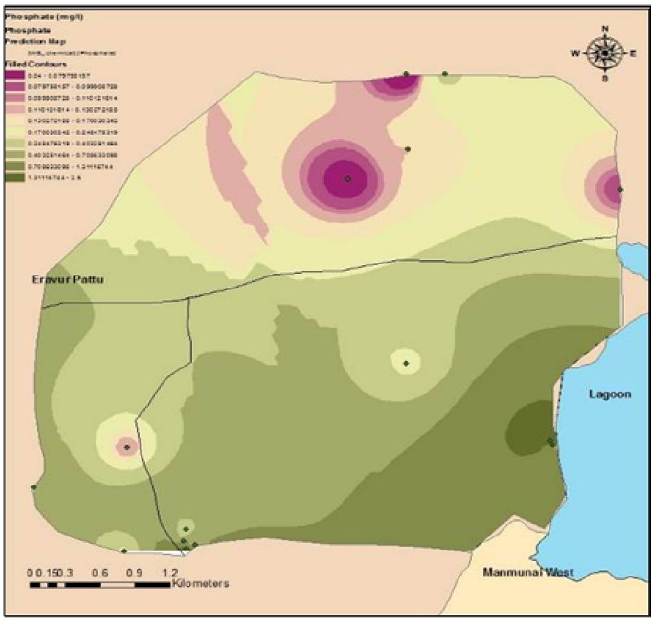

Fig.7. Spatial Variation Map of Phosphate

Tilman*et al*., (2002) indicates that the global use of nitrogen and phosphate fertilizer has increased about 8 and 3.5 times respectively in the period of 1960 to 2000. A significant amount of these nutrients is lost from agricultural fields, due to diminishing returns. Hence, such non-point nutrient losses are a primary determinant of groundwater contamination (Nikolaidis, 2007).

Conclusion

The present study has been carried out to analyze the spatial variation of major groundwater quality parameters such as pH, Electrical conductivity, Total Dissolved Solids, Nitrite, Nitrate and Phosphate using GIS approach. The parameters clearly showed a spatial variation in the study area. The intrusion of lagoon water, intensive agricultural practices, exploitation of ground water, unplanned constructions of well and seasonal variations are some of the major factors influence the spatial distribution of water parameters. The mapping gives awareness to the community as well as to the other institutions to identify the possible risks when undertaking further development in the particular area.

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