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MAPPING SPATIAL DISTRIBUTION OF WATER QUALITY PARAMETERS USING GIS IN GROUNDWATER OF THE KELANI RIVER BASIN, SRI LANKA

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Abstract- The demand for water in Sri Lanka is gradually increasing with accelerated development, mainly for human consumption, agriculture, recreational and industrial requirement. This necessity is exerting considerable weight on the available groundwater resources. Kelani river basin is the third largest watershed of the country and considered as the main water source for the greater Colombo which is the main commercial and capital city of the country. The present study focused on application of GIS for graph spatial distribution maps referring for important water quality parameters of the ground water in the Kelani river basin. Total 72 ground water sampling locations were selected for the study and some physico-chemical and microbiological parameters were recorded using the standard methods. Most of the wells sampled for the study are being used for drinking purposes. It was found that well water in the later part of the transitional zone of the river basin has acidic nature (4.24-6.14). 90% of sampling locations showed high COD and BOD values were detected in meandering zone compare to transitional and head region of the river basin. 70% of groundwater sampling locations were contaminated with total coliform bacteria where 45% of sampling locations were contaminated with feacal coliform. Conductivity, TDS and hardness values of water were showed increasing trend from the head region through the transition to meandering region. Nitrate, Nitrite and phosphate concentrations were remained acceptable level for Sri Lanka Standards for drinking water (SLS). GIS spatial distribution maps give better visual image to understand the spatial distribution pattern to overlook better conclusion. The results of the study showed increasing trend of the pollution load towards the meandering part of the river basin suggesting proper management strategic plan is needed to protect groundwater resources of the Kelani river basin.

Keywords- Kelani river basin, Ground water, Physico-chemical and microbial parameters, Spatial distribution maps.

I. INTRODUCTION

Ground water is an essential and most important component of human life support system and it needs for drinking, domestic, industries and irrigation purposes. Activities such as irrigation, industrialization and urbanization are usually affected on the ground water quality [1, 2, 3]. Shallow characters and high permeability of ground water makes highly susceptible to pollution and once the groundwater is contaminated, its quality cannot be restored back easily [4]. Several materials have been identified as contaminants found in groundwater such as synthetic organic chemicals, hydrocarbons, inorganic cations, inorganic anions, radionuclides and pathogens [5]. In Sri Lanka, about 80% of the rural domestic water supply needs are supply from groundwater by means of dug wells and tube wells. In many areas in Sri Lanka where surface water and pipe borne water systems are not fully reliable and most of the industries in the country are depend heavily on ground water because of its good quality and self-manageability [6]. The Kelaniriver is one of the major river in Sri Lanka and its starting from the Nallathanniya which locates in the central highlands in the country and end from the Mattakkuliya which locates Colombo the main commercial and capital city in of the country [7]. It is 144 km long and drains an area of 2,230 km^2 and it could be ranked as the largest recipient of various types of industrial effluents of the country [8, 9]. It has been documented that, six main types of groundwater aquifers have been identified in Sri Lanka and the Kelaniriver have broad and deep alluvial beds of variable texture and gravel content in the lower reaches [6]. Lower part of the Kelani river basin content high groundwater yield and a reliable volume of groundwater can be extracted from these alluvial aquifers throughout the year [6]. Geographic information system (GIS) has developed as a powerful tool for analyzing, storing and displaying spatial data and using these data for decision making in several areas including engineering and environmental fields [10, 11, 12]. In groundwater, GIS is commonly used for site suitability analyses, estimation of groundwater vulnerability to contamination, groundwater flow modeling, modeling solute transport and leaching and integrating groundwater quality assessment models with spatial data to create spatial decision support systems for groundwater studies [13,14]. Water management in Kelani river basin is important for present and future development of the country [7]. Groundwater quality assessment is important to ensure sustainable safe use of water, therefore aim of the present study is to provide an overview of groundwater quality condition of the Kelani river basin. Therefore, spatial distribution maps for some selected water quality parameters were used to evaluate the quality of ground water in the Kelani river basin for drinking and industrial utilization purposes in the present study.

II. DETAILS EXPERIMENTAL

2.1 Materials and Methods

2.1.1. Study area

Kelani river basin is located at northern latitudes 6° 47' to 7° 05' and eastern longitudes 79° 52' to 80° 13' with the area of 2230 km^2. Kelani river basin is the home to more than 25% of the Sri Lankan population and provides about 80% of the drinking water to Colombo area [15].

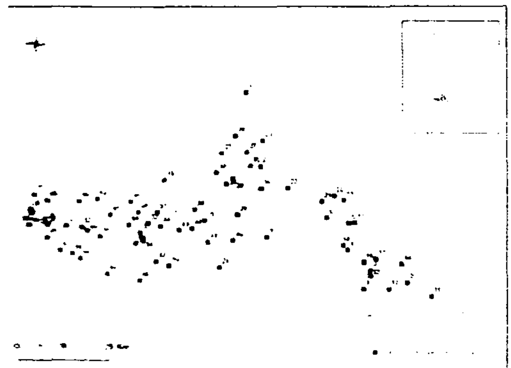

Fig 1. Ground water sampling locations of the Kelani river basin.

2.1.2 Sampling

Groundwater samples were collected from predetermined wells based on the land use practices. A total of 72 water samples were collected from different sampling sites including head, transitional and meandering region of the Kelani river basin (Fig. 1 & Table 1). Pre-cleaned polypropylene bottles were used to collect water samples for chemical analysis [illegible] and sterile glass bottles were used to collect water for microbial analysis. Water samples were kept in the ice box at 4^{0}C from collection until reach to the laboratory. The GPS coordinates of the [illegible] were recorded by GPS (Hand-held Gamin [illegible] 30 GPS receiver).

2.1.3 Water quality and GIS analysis

[illegible] methods were used for sample collection, [illegible] and analysis of different water quality [illegible] [17]. Electrical Conductivity (EC), Total Dissolved Solids (TDS) and salinity were measured [illegible] portable conductivity meter (HACH - [illegible] EC5) and water temperature, pH and Dissolved Oxygen (DO) were measured using HQD [illegible] meter (HACH - HQ 40D) at the site [illegible] Biological Oxygen Demand (BOD5) was [illegible] by using Winkler method where nitrates, [illegible] total phosphate (TP) concentrations were [illegible] by Spectrophotometric (Spectro UV-VIS [illegible] 2960) methods [17]. Titrimetric method [illegible] EDTA was used to determination of total [illegible] and Chemical Oxygen Demand (COD) [illegible] using closed reflux method. Microbiological quality (Total coliform (TC) and Feacal Coliform (FC)) was determined by the standard Most Probable Number (MPN) method [17]. Inverse distance weighted (IDW) technique of spatial analysis tool was used in ArcGIS 10 version for data analysis.

Table 1: Sampling locations of the Kelani river basin.

No	Head region	No	Transitional region	No	Meandering region
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	26	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	Waga	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Athis	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

III. RESULTS AND DISCUSSION

The pH in the study area was ranges between 4.1 (Thalangama) to 7.9 (Aliwaththa) and most of the locations of the lower part of transitional zone of the river basin having acidic nature (<5.0) which not fulfill the maximum permissible limits for drinking water given by SLS standards (6.5-8.5) (SLS 614, 2013) (Fig.7). Point of Environmental health low pH of drinking water can cause gastrointestinal disorder [18]. Thus, it is important to monitor water quality of ground water to safeguard people who consume ground water for drinking purposes. The conductivity values were ranged from 12.5 μs/cm to 1105.1 μs/cm and the lowest was recorded "Athis" sampling point which is a spring located in central highlands. The highest conductivity was recorded in Aliwaththa sampling location (Fig. 8). TDS values were between 13.52 mg/L (Waga) to 725.10 mg/L (Aliwaththa). The overall conductivity and TDS of water in the study area showed increasing tendency towards the down part of the river basin. This may due to loading and accumulation of ionic compounds, contaminants via surface water runoff and industrial effluent and urbanized cites of the catchment [19]. The results of the study showed that the total hardness of the river basin was ranged between 4.00 mg/L (Viharakumbura) to 86.00 mg/L (Peliyagoda) (Fig: 9) and the recorded values were within the safe level for drinking water quality (250 mg/L) standards given by the SLS (SLS 614, 2013)[20]. However, it was found that increasing tendency of hardness towards the down part of the river basin. Conductivity, TDS and hardness values were also high in Pitagaldeniya area this may due to soil condition of the area. Nitrate and nitrite concentrations of the study area remained between 0.03 mg/L (Kambulumulla) to 24.8 mg/L (Thalangama) (Fig: 5) and 0.45 µg/L (Deraniyagala) – 5.5 µg/L (Nawagampura) (Fig: 4) respectively. All most all the sampling points, nitrate and nitrite concentrations were below the concentration given by SLS for drinking water (45 mg/L and 10µg/L. SLS 614:1983)[21]. Municipal wastes deposited contribute higher values of nitrates and nitrites with increase human population [22]. Interestingly, the highest values of nitrate and nitrite concentrations were recorded from the Colombo district where contribute high pollution load to surface and ground water via anthropological activities. Spatial distribution pattern of nitrate and nitrite (Fig: 4 and 5) is showed that the end part of the meandering zone of the river basin receive much more pollutant enrich with nitrogen sources. DO values were ranged between 0.80 mg/L and 8.24 mg/L. Most of the surface and ground water locations in the meandering part of the river basin showed low DO concentrations. This may due to high organic load which enhance microbial activity with high BOD and TDS. Thus, dissolved oxygen concentrations provide meaningful information about water quality regarding the stability of many organic and inorganic contaminants in ground water. The spatial distribution map (Fig 2) for BOD indicates that the groundwater sampling locations in later part of the river basin was suffered due to continuous discharge of domestic, industrial and municipal sewage. Mahagamage et.al. 2013[23], recorded high BOD and COD values in ground water of head and meandering zones of the Kelani river basin. Then same pattern of BOD (8.50 mg/l -Mahawaththa) and COD (230.80 mg/l -Kudagama) were recorded in the present study as well (Fig: 3). Direct discharges of untreated domestic waste and waste water into the river and to the basin enhance the BOD and COD concentrations in water. It has been documented that high organic pollution directed to very high BOD and COD load in the water [24]. Regarding phosphate, normally groundwater contains only a minimum phosphorus level because of the low solubility of native phosphate minerals and the ability of soils to retain phosphate [25]. Results of the study showed that phosphate concentration was ranged between 5.13 µg/L (Ederamulla) to 1444.81µg/L (Peliyagoda) (Fig 6) and remained within the standards given by the SLS 614 2013 (2000µg /L) [20]. Interestingly, it was found that almost more than 70% of ground water samples were contaminated by total coliform (Fig 10) where 45% of ground water wells were contaminated with feacal coliform (Fig 11). Spatial distribution showed the head and meandering regions of the river basin more contaminated with total and fecal coliform bacteria than transitional region. The later part of the meandering zone of the river basin showed high total and feacal coliform contamination (MPN value 1100<) indicate that microbial contamination of water may due to poor sanitary conditions in the vicinity of the area.

Fig .2. Spatial distribution pattern of BOD in the Kelani river basin.

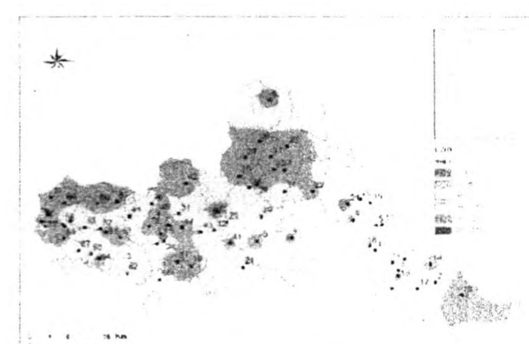

Fig.3. Spatial distribution pattern of COD in Kelani river basin.

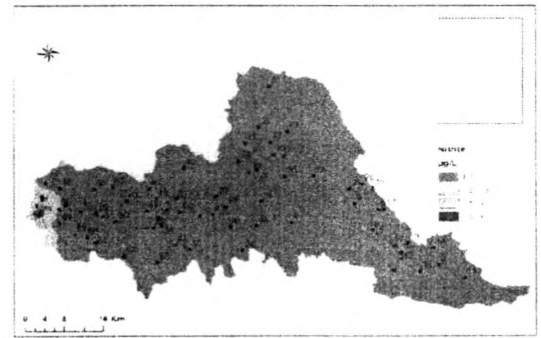

Fig.4. Spatial distribution pattern of nitrite in Kelani river basin.

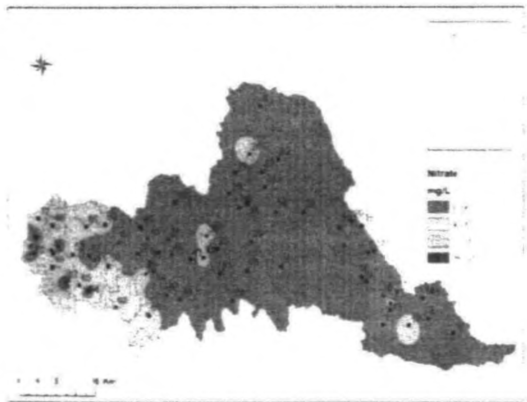

Fig.5. Spatial distribution pattern of nitrate in Kelani river basin.

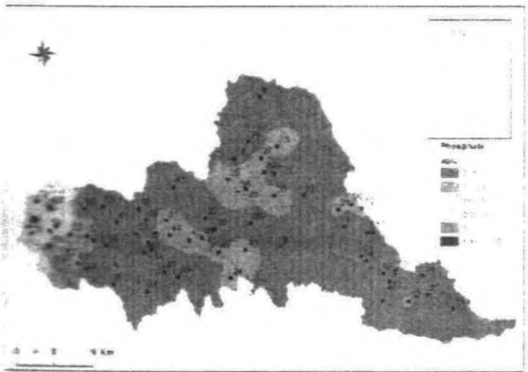

Fig.6. Spatial distribution pattern of total phosphate in Kelani river basin.

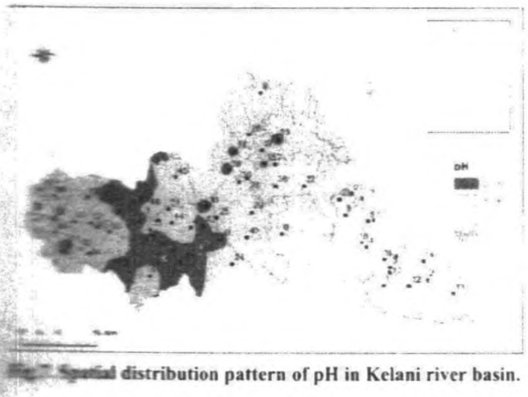

Fig.7. Spatial distribution pattern of pH in Kelani river basin.

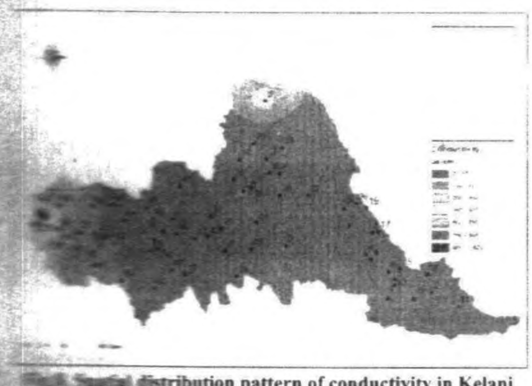

Fig.8. Spatial distribution pattern of conductivity in Kelani river basin

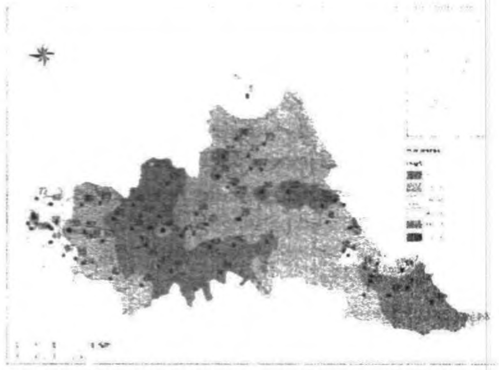

Fig.9. Spatial distribution pattern of hardness in Kelani river basin.

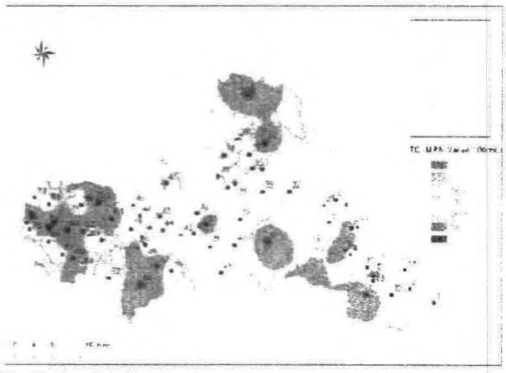

Fig.10. Spatial distribution pattern of TC in Kelani river basin.

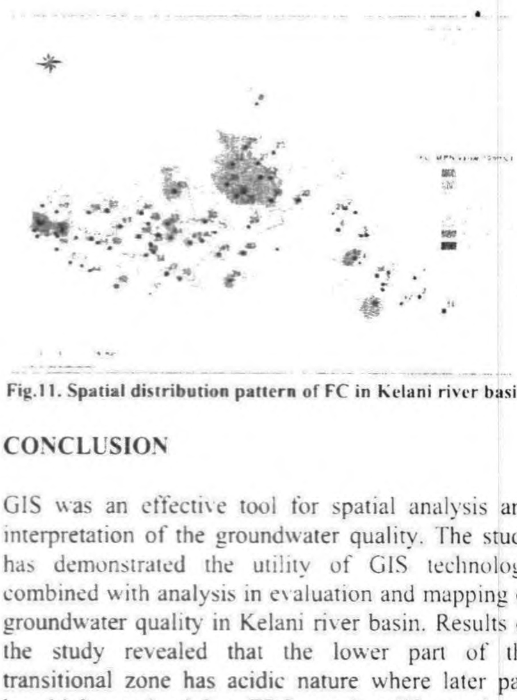

Fig.11. Spatial distribution pattern of FC in Kelani river basin.

CONCLUSION

GIS was an effective tool for spatial analysis and interpretation of the groundwater quality. The study has demonstrated the utility of GIS technology combined with analysis in evaluation and mapping of groundwater quality in Kelani river basin. Results of the study revealed that the lower part of the transitional zone has acidic nature where later part has high conductivity, TDS, total coliform, feacal coliform, nitrite, BOD and hardness which indicate increasing tendency of all parameters towards to the down part of the Kelani river basin. Meandering zone of the Kelani river basin is having highly populated areas, industries; urbanized cities which are produce pollutants to the environment. Thus, the GIS spatial distribution maps give better visual picture to understand the present ground water quality of the Kelani river basin to overlook for better conclusion. The results suggest that the groundwater of the meandering part of the Kelani river basin needs some of treatment before consumption and it is indicating need to develop suitable management practices to protect the ground water resources in Kelani river basin.

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