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Assessment of Groundwater Quality Status in Medawachchiya DS Division in Anuradhapura District, Sri Lanka

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Abstract— **Medawachchiya DS division in Anuradhapura district is a major agricultural area. Majority of people depend on groundwater for their domestic consumption and agricultural activities. Farmers apply excess amount of chemical fertilizers and pesticides in crop production and a number of CKDu patients are identified in this division. Hence, analysis of groundwater quality in this region is vital to ensure its suitability for various purposes. The present study aimed to assess the groundwater quality in Medawachchiya DS division. Groundwater samples at 25 locations were collected and analysed for major physio-chemical parameters. Water Quality Index (WQI) was estimated to assess the suitability of groundwater for drinking purpose. Results releveled that the quality of groundwater varies spatially in the study area. Groundwater near industrial and dumping sites was acidic. The Color and Turbidity of groundwater exceeded the permissible limit at Kadawathrambewa and Medawachchiya West. Groundwater at more than 50% of the sampling locations was very hard The TDS and Alkalinity levels exceeded the maximum permissible limit at 52% of the sampling locations. Fluoride content was above the acceptable limit at 20% of the sampling locations. The elevated level of Nitrate and Phosphate were observed in the farming areas. However, the Chloride level was within the acceptable limit. According to the estimated WQI, the quality of groundwater was excellent at 44% of the sampling locations. However, groundwater quality at Abayapura, Helabagaswewa, Walpola, and Wiralmurippuwa was very poor and the groundwater at Mahakubukgollewa was unsuitable for drinking purpose. Promoting the usage of organic manure in agriculture, monitoring the industrial wastewater discharge, and converting the open dumpsite to sanitary landfill would be viable options to reduce groundwater pollution in these areas.**

Keywords- **Groundwater pollution, WQI, Water quality**

I. INTRODUCTION

Groundwater is recognized as a potential water resource to enhance the productivity of both agricultural and industrial sectors. It has been the most important water resource, particularly for drinking purpose due to limited surface water resources in the dry zone of Sri Lank. However, the quality of the groundwater has a great impact on human health and associated socio-economic development. As per the previous studies [1], [2], [3], groundwater resource has already been deteriorated in many places in the country due to improper management. Therefore, assessing the quality status of groundwater is become vital to ensure its safe use for various purposes including drinking [4].

The majority of people in the Medawachchiya DS division in Anuradhapura district use groundwater as the main source of water for drinking purpose. In this area, farmers practice traditional agricultural practices and over use of agrochemicals in farming is observed in this area. Excess application of agrochemicals in farming areas polluted the vital groundwater resource in dry zone [3]. Further, number of CKDu patients are identified and the consumption of groundwater is suspected to be the cause for health issue in this division. However, the quality status of groundwater in this division is not well documented. This study, therefore, aimed to assess the suitability of groundwater for drinking purpose in Medawachchiya DS division in Anuradhapura district.

II. MATERIALS AND METHODS

A. Study area and sampling locations

This study was conducted in the Medawachchiya DS division in Anuradhapura district, Sri Lanka. Groundwater samples from 25 locations were collected for analysis. Figure 1 shows the study area and sampling points. Pre-cleaned 500 ml polypropylene bottles were used to collect water samples from dug wells. GPS device was used to get the coordinates of sampling points. Collected water samples were transported in cold condition using ice boxes within 24 hours and stored in cold room at 4^0C until analysis.

B. Analysis of water quality parameters

The pH and TDS were measured using portable pH and TDS Meter, respectively at the sampling site. All the laboratory analysis was done at National Water Supply & Drainage Board (NWSDB), Godage Mawatha, Anuradhapura. The Color of groundwater was measured using Spectrophotometer and the Total Hardness (TH) was measured by titration with EDTA. Total Alkalinity (TA) was determined by titrating the groundwater sample with Sulphuric acid of known pH, volume and concentration. Nitrate and Phosphate were measured using Spectrophotometer. Determination of chloride content was done by titration with silver nitrate solution. Fluoride was measured by mixing water with Zirconyl Xylenol orange complex reagents.

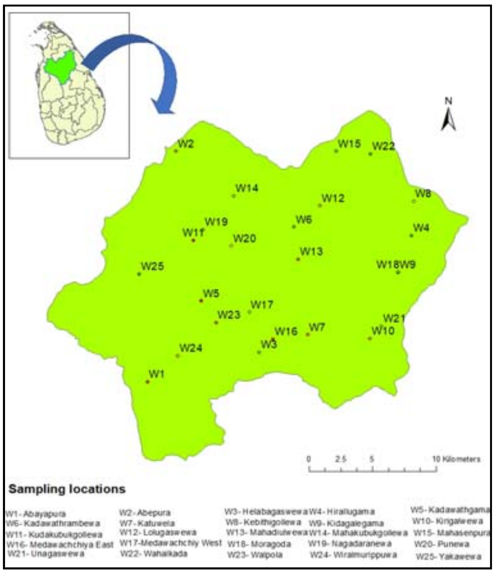

Fig. 1: Sampling locations

C. Estimation of Water Quality Index (WQI)

In this study, WQI was estimated based on Sri Lankan standards as proposed by [5]. Equation 1 was used to estimate the WQI.

$$WQI = \sum_{i=1}^{n} W_i \, q_i \qquad (1)$$

Where, WQI – Water quality index of the collected groundwater sample, Wi - relative weight of the quality parameter and qi is the quality rating. Equation 2 was used to estimate the relative weight of the quality parameter.

$$W_i = \frac{w_i}{\sum_{i=1}^{n} w_i} \qquad (2)$$

Where, Wi - relative weight of the quality parameter, wi - weight of each parameter and n - number of quality parameters used to estimate WQI. Equation 3 was used to estimate the quality rating.

$$q_i = \frac{C_i}{S_i} \times 100 \qquad (3)$$

Where, qi- quality rating, Ci- concentration of quality parameter in groundwater sample in mg/l, Si - Sri Lankan drinking water standard in mg/l (Table 1).

TABLE 1: RELATIVE WEIGHT FOR WQI WITH SRI LANKAN STANDARDS

Chemical parameter	**Sri Lankan Standard**	**WHO guideline**	**Weight (wi)**	**Relative Weight (Wi)**
pH	6.5-8.5	6.5-8.5	4	0.1212
TDS(mg/l)	500	500	5	0.1515
TH(mg/l)	250	-	2	0.0606
TA(mg/l)	200	120	3	0.0909
Fluoride(mg/l)	1	1.5	5	0.1515
Chloride(mg/l)	250	250	4	0.1212
Nitrate(mg/l)	50	50	5	0.1515
Phosphate(mg/)	5	5	5	0.1515
			∑wi=33	*∑Wi=1.0000*

III. Results And Discussion

A. pH

Generally, pH of drinking water falls within the range of 6.5-8.5 [6]. The pH of groundwater in the study area ranged from 5.08 to 7.53 (Figure 2). Maximum pH of 7.53 was observed at Mahakubukgollewa (W14) and the lowest pH of 5.08 was observed at Nagadaranewa (W19) (Figure 2). A pH value below 6.5 is considered as acidic water. Accordingly, groundwater was acidic at 36% of the sampling locations (W4, W7, W13, W15, W16, W17, W18, W19 and W22) in the study area. Low pH level in groundwater was found in the vicinity of industrial and dumpsites. Similar findings were also reported by [7].

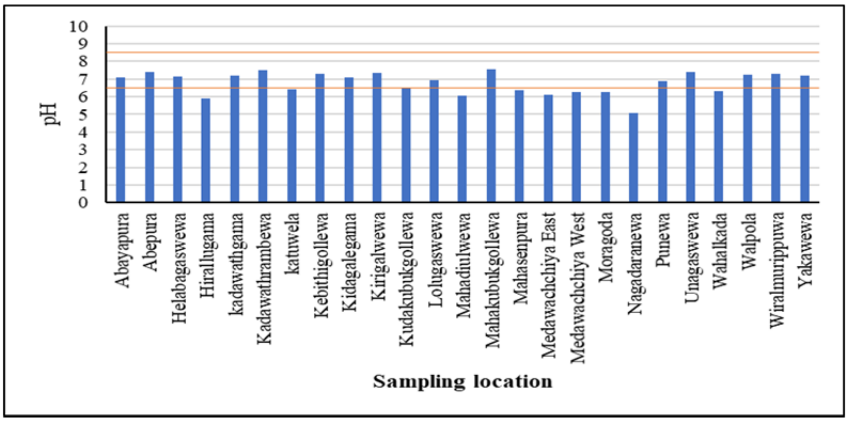

Fig. 2. Variation of pH in groundwater in the study area

B. Colour

Colour of groundwater ranged from 0.2 to 40 Hazen. Maximum colour value of 40 Hazen was observed at Kadawathrambewa (W6) and minimum colour value of 0.2 Hazen was observed at Mahasenpura (W15) (Figure 3). Colour depends on several factors of which neutral salt, colloidal suspensions and non-colloidal organic acids found in water are important. According to WHO, Colour of water should fall within the range of 0 - 15 Hazen for drinking water. An acceptable range of Color was found at all places except Kadawathrambewa (W6) and Medawachchiya West (W17). High amount of wastes from animal, household and industrial sites dissolved in groundwater might have contributed for higher level of Color in these areas.

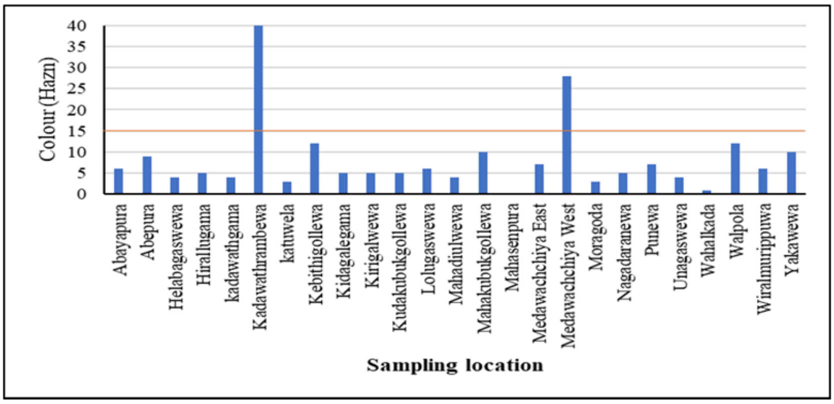

Fig. 3. Variation of Colour of groundwater in the study area

C. Turbidity

Turbidity of groundwater ranged from 0.09 to 36 NTU. Maximum value of 36 NTU was observed at Kadawathrambewa (W6) and the minimum value of 0.09 NTU was observed at Kadawathgama (W5) (Figure 4). Water appears cloudy or murky when suspended particles or dissolved particles scatter the passing light. According to WHO, Turbidity of drinking water should not be more than 5 NTU and ideally below 1 NTU. Turbidity of groundwater collected from Kadawathrambewa (W6) and Medawachchiya West (W17) exceeded the maximum permissible limit.

D. TDS

The TDS expresses the presence of inorganic salts and small amounts of organic matter in water. The TDS of groundwater ranged from 17-926 mg/l in the study area (Figure 5). Maximum value of 926mg/l was observed at Mahakubukgollewa (W14), whereas the lowest level of TDS was observed at Kadawathgama (W5) and Mahasenpura (W15).

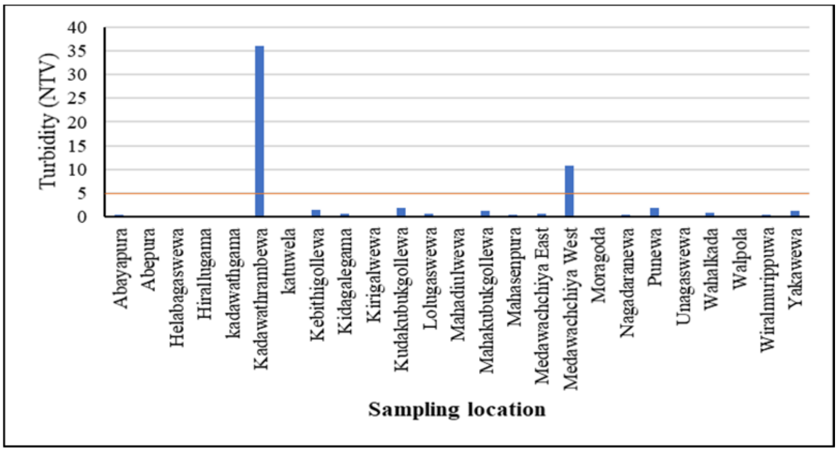

Fig. 4. Variation of Turbidity in groundwater in the study area

According to WHO, TDS range of less than 300mg/l is recommended for drinking water. Accordingly, TDS level of groundwater at 52% of the sampling locations exceeded the recommended level in the study area.

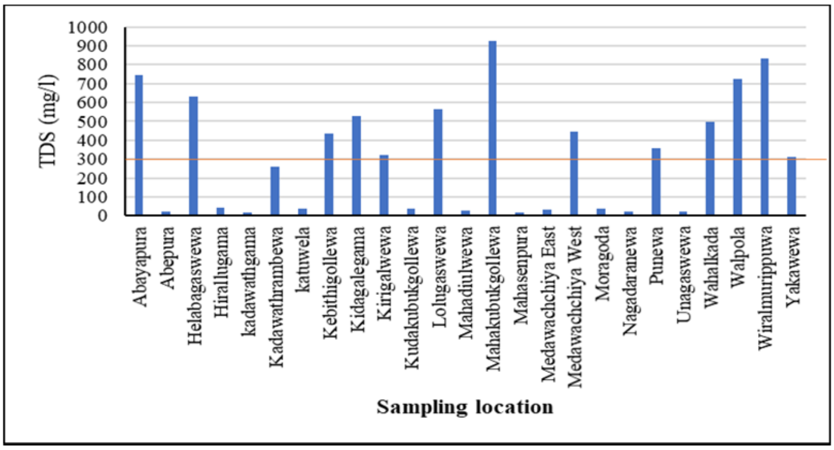

Figure 5: Variation of TDS in groundwater in the study area

E. Chloride

Chloride content of groundwater ranged from 8 to 250 mg/l (Figure 6). Maximum value of 250 mg/l was observed at Mahakubukgollewa (W14) and the minimum value of 8 mg/l was observed at Kadawathgama (W5). As per the WHO the taste threshold for Sodium chloride and Calcium chloride in water is in the range of 200-300mg/l. As recommended by EPA, Chloride level should not be higher than 250mg/l to avoid salty tastes and undesirable odors. Further, use of water with the high level of Chloride can corrode and weaken metallic piping and fixtures give a salty taste to drinking water.

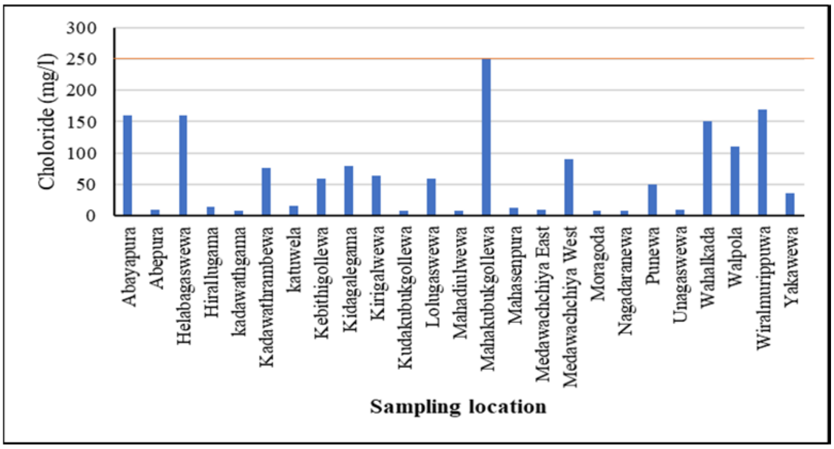

Fig. 6. Variation of Chloride in groundwater in the study area

F. Total Hardness (TH)

Hardness is most commonly expressed as milligrams of Calcium Carbonate equivalent per liter. In the study area, TH of groundwater ranged from 8 to 490 mg/l (Figure 7). Maximum TH of 490 mg/l was observed at Mahakubukgollewa (W14) and the minimum value of 8 mg/l was observed at Kadawathgama (W5). As defined by [8], water containing Calcium Carbonate at concentrations below 60 mg/l is soft. Water with concentrations ranging from 60-120mg/l and 120-180mg/l are considered as moderate and hard water, respectively. However, water with a concentration above 180 mg/l is designated as very hard.

Accordingly, groundwater at 44% of the sampling locations was soft whereas it was very hard at 52% of the locations.

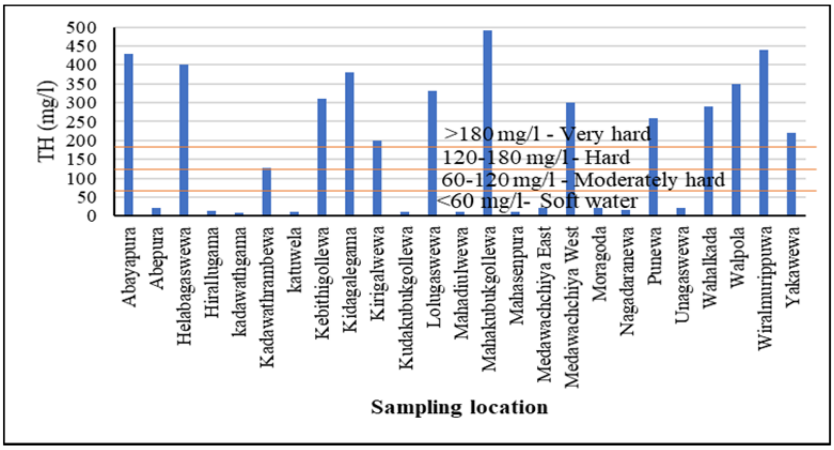

Fig. 7. Variation of TH in groundwater in the study area

G. Nitrate

Figure 8 illustrates the variation of Nitrate level in groundwater in the study area. Nitrate contents of groundwater ranged from 0.003 to 3.08 mg/l. Maximum value of 3.08 mg/l was observed at Mahakubukgollewa (W14) while minimum value of 0.003 mg/l was observed at Kudakubukgollewa (W11). Wells in agricultural areas throughout the world especially contribute to nitrate-related toxicity problems, and nitrate levels in the well-water often exceed 50 mg/l [9]. The EPA standard for Nitrate in drinking water is 10 mg/l. However, WHO prescribed Nitrate level in drinking water is usually below 0.1mg/l [10]. Accordingly, elevated nitrate content was observed at many locations in the study area. Elevated levels of nitrate observed at W10 and W14 may be due to excessive use of urea fertilizers in these areas.

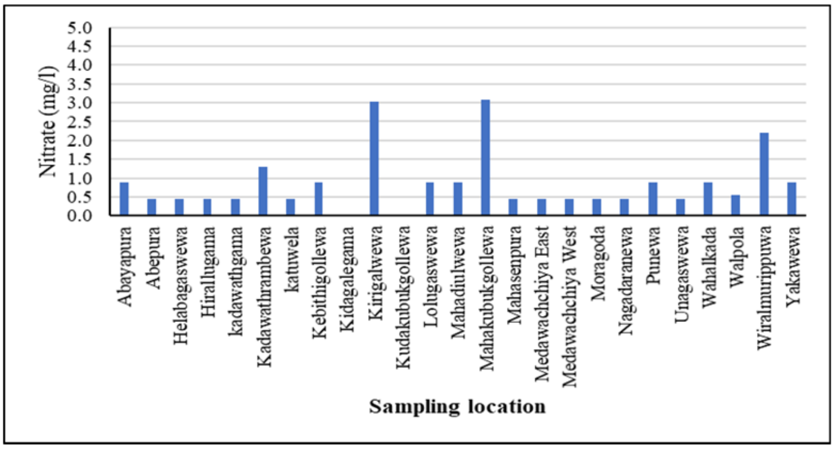

Fig. 8. Variation of Nitrate in groundwater in the study area

H. Flouride

Fluoride is often called a two-edge sword – in small dosages, it has remarkable influence on the dental system by inhibiting dental carries, while in higher dosages more than 1.5 mg/l causes molting of teeth, lesion of endocrine glands, thyroid, liver and other organs [11]. The Fluoride content in groundwater ranged from 0.01 to 1.5 mg/l. Maximum value of 1.5 mg/l was observed at Kadawathrambewa (W6) and minimum value of 0.09 mg/l was observed at Unagaswewa (W21) (Figure 9). Although the recommended level of Fluoride in drinking water ranges from 0.6 to 1.5 mg/l [10], Flouride level below 1 mg/l is desirable. Water at many locations was rich in Fluoride.

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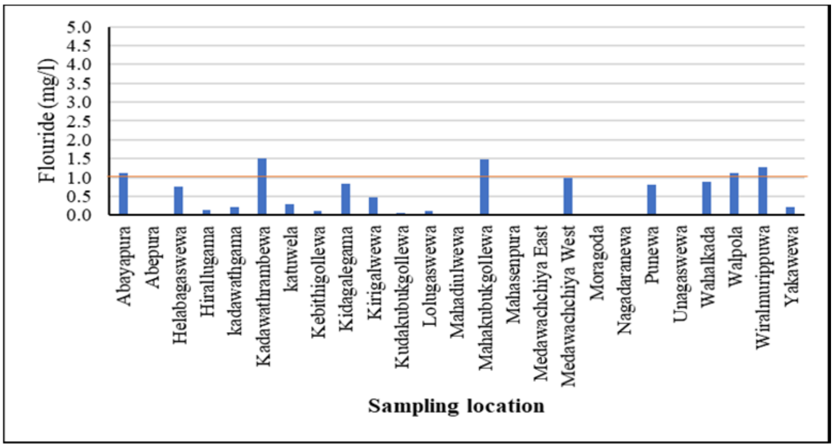

Fig. 9. Variation of Flouride in groundwater in the study area

I. Total Alkalinity (TA)

Alkalinity expresses the presence of Carbonate, Bicarbonate and Hydroxide in water. Figure 10 shows TA of groundwater samples collected at various locations in the study area. TA ranged from 10 to 470 mg/l. Maximum value of 470 mg/l was observed at W1 and minimum of 10 mg/l was observed at W5. The allowable range of Alkalinity in drinking water is 20-200 mg/l. Alkalinity in groundwater exceeded the maxim permissible level of 200 mg/l at 52% of the sampling locations in the study area.

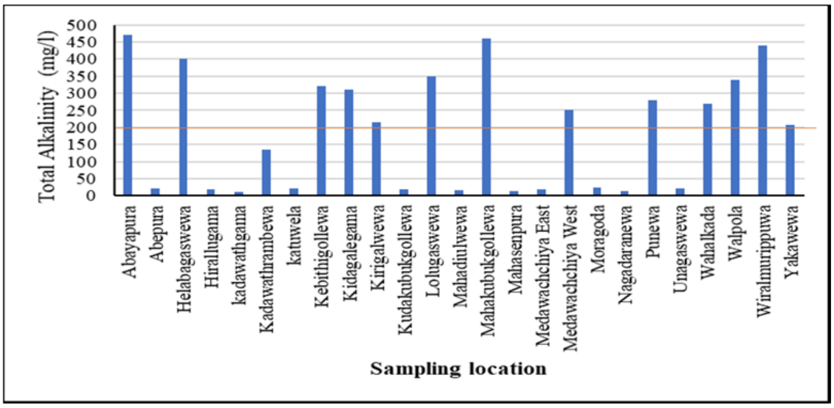

Fig. 10. Variation of Total Alkalinity in groundwater in the study area

J. Total Phosphate

Total Phosphate ranged from 0.02 to 4.80 mg/l (Figure 11). Maximum value of 4.80 mg/l was observed at Lolugaswewa (W12) and minimum value of 0.02 mg/l was observed at Mahasenpura (W15). Low Phosphate level at W13, W23, W16, W2 and W15 was less than 0.05 mg/l.

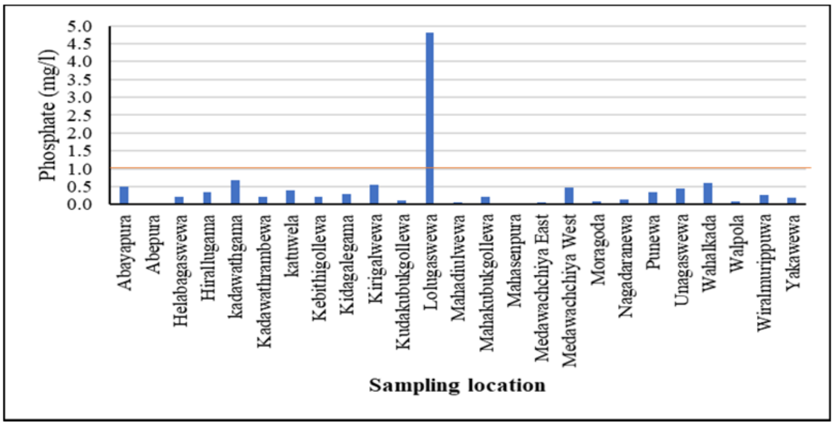

Fig. 11. Variation of Total Phosphate in groundwater in the study area

Lolugaswewa, where the highest Phosphate level was observed, has 5000 ha of paddy field and the farmers apply excessive levels of chemical fertilizers. The maximum permissible limit of Phosphate is 5 mg/l. However, Phosphate concentration below 1 mg/l is preferred in drinking water.

K. Water Quality Index (WQI)

Figure 12 shows the variation of WQI of groundwater taken at different locations in the study area. WQI ranged from 11.5-110. The highest WQI was observed at Mahakubukgollawa (W14) whereas the lowest WQI was observed at Nagadaranewa (W19).

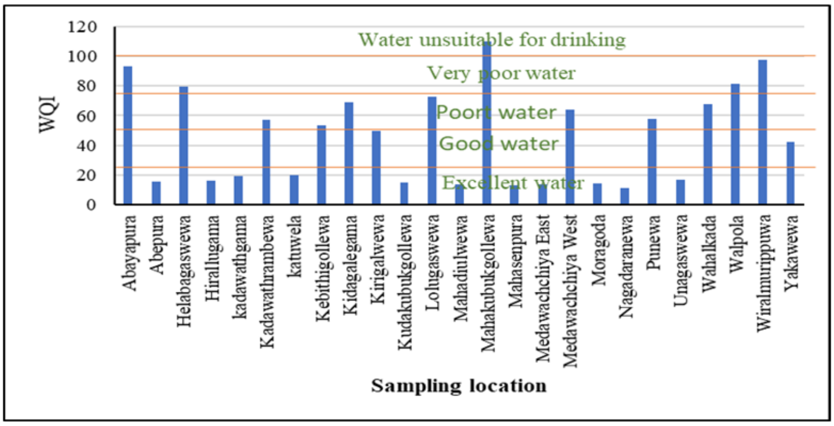

Fig. 12. Variation of WQI in groundwater in the study area

Water sample could be catogorized into different classes based on WQI value as shown in Table 2. Groundwater collected from 44% of the locations was excellent in quality. The WQI ranges from 26-50 is considered as good water.

TABLE 2: CLASSIFICATION OF GROUNDWATER ACCORDING TO WATER QUALITY INDEX (WQI)

Class	WQI range	Water type
1	0-25	Excellent Water
2	26-50	Good Water
3	51-75	Poor Water
4	76-100	Very Poor Water
5	>100	Water Unsuitable for Drinking

Accordingly, groundwater collected from 52% of locations was good. However, 28% of water samples were poor and 16% was very poor in terms of quality. Groundwater collected from Mahakubukgollewa was unsuitable for drinking purposes. Figure 13 shows spatial variation of groundwater quality in the study area based on WQI. Accordingly, groundwater quality in the study area shows high spatial variations.

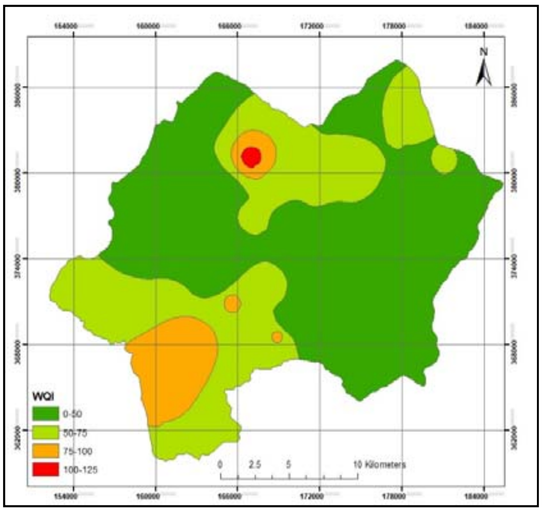

Fig. 13. Spatial variation of WQI in groundwater in the study area

IV. Conclusions

Groundwater quality spatially varies in the study area. The level of pollutants in the groundwater exceeds the maximum permissible limit at many sampling locations, particularly near the dumpsites, industrial sites and in the agricultural areas. According to the suitability class, groundwater is not safe for drinking in many places in the study area. Promoting the usage of organic manure in agriculture, monitoring the industrial wastewater discharge, and converting the open dumpsite to sanitary landfill would be viable options to reduce groundwater pollution in these areas.

V. Acknowledgment

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