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International Journal of Research and Innovations in Earth Science
Volume 2, Issue 6, ISSN (Online) : 2394-1375

Physico-Chemical Analysis of Drinking Water from the Collector Wells in Vallipuram Costal Area of the Jaffna Peninsula, Sri Lanka

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***Abstract* – Ground water is one of the principal sources of water for domestic use in Sri Lanka. Water should be safe for consumption and it should be free from pathogens, poisonous substances and excessive mineral and organic matter. Jaffna peninsula mainly depends on the ground water for drinking, agriculture and industry. The quality of ground water is getting deteriorated due to diverse factors. The study was aimed at assessing the water quality of the collector wells in the Vallipuram area of the northern Sri Lanka and to determine the suitability of the water for domestic utilization. Water samples were collected from the four water supply collector wells in both top and bottom randomly in duplicates during the dry season of 2015. Samples were analyzed for pH, electrical conductivity (EC), chloride, total alkalinity, total acidity, total dissolved solids (TDS) and total hardness. The results were compared with WHO and SLS standards. The samples obtained from the first, third and fourth collector wells do not contain any contaminants and the samples obtained from the second collector well contained iron contaminant. The quality of the water in the collector well two is not suitable for drinking but can be used for irrigation after appropriate water treatment like chlorination. This study reveals that all the values obtained are within the permissible limit in all levels of the collector wells apart from the excessive amount of iron in the collector well 2, according to WHO standard.**

***Keywords* – Collector Wells, Water Quality, Alkalinity, Acidity, Chloride, TDS, Vallipuram.**

I. Introduction

Water is one of the principal components in determining the quality of the human live. Although water covers about 70 percent of the earth's total surface, only 0.3 % of it can be utilized by humans (Dhivyaa pranava et al., 2009). Among the various source of water, ground water is considered to be the largest reservoir of drinking water. Jaffna Peninsula of Sri Lanka has a low percentage of surface water sources because of its karstic nature and flat terrain (Dissanayake and Senaratne, 1981; Senaratne and Dissanayake, 1982; Wijesekera et al., 2012; Jayalakshmi et al., 2011, Hidayathulla and Karunaratna, 2013). People in Jaffna peninsula, depend mainly on ground water for their drinking and other domestic needs due to the unavailability of other water sources such as water falls, rivers and fresh water ponds and insufficiency of water available from rainfall. However, the ground water in Jaffna is suspected to be in danger due to over exploitation and pollution caused by excessive usage of agrochemicals and fertilizers. Collector wells with large diameter are the principal source of water supply in many part of the world for domestic purposes and agriculture usage (Herbert and Kitching, 1981). Groundwater from collector wells has been the key source of drinking water for a vast majority of the population of Sri Lanka for thousands of years (De silva and Weatherhead, 1994). The existence and availability of the ground water mainly depend on the characteristics and distribution of varying litho-geochemical parameters of the geological location (Health Canada, 1992 and 2007). The high stress on ground water due to the abstraction of large quantities of ground water through pumping for irrigation and water supply has created threats to the sustainability of this natural resources (Gray, 1994 and Gulta et al., 2009).

The water reservoir found in the saturated part of the ground underneath the land surface is called ground water. When the water seeps into the ground and moves downward due to the gravity of earth through the pore spaces found between soil particles and cracks in rock, water will get accumulated (USEPA, 2014). Ground water is an important source of water supply with substantial benefits. Ground water is commonly colourless, free from pathogenic organism due to infiltration, turbidity generally absent, and stable chemical composition. Despite these merits, however ground water is susceptible to be polluted by the human activities (Aiyesanmi et. al., 2008, Gulta et al., 2009). Ground water is very important source for agricultural and domestic use especially in the developing countries like Sri Lanka, due to the long retention time. Water should be safe for drinking all the time and it should be free of pathogens, poisonous substances and excessive mineral and organic matter (WHO 2004). Although water is an indispensable commodity for sustenance of life, it will be very dangerous with it is polluted with industrial, agricultural or domestic waste or even other chemicals and metals in excess amount. These will make the water unacceptable for its usage. Any substance that causes such undesirable changes in the water quality is known as a pollutant. Assessment of the concentration of chemicals and other pollutants in ground water will help to ensure the safe water supply and to minimize the threats to human health (Dhivyaa pranava et al., 2009).

Manalkadu Sand Dunes - Manalkadu village is a mini version of a desert. Right at the town of Point Pedro begins the Manalkadu Sand dunes. The sparsely populated coastal stretch is punctured with isolated villages centred around a village well. The acres of sand dunes are also found covered with thick bush while beyond the dunes one can spot one of the most beautiful beaches of the Northern Province. Sand dune, sand dune: Sand dunes are comparable to other forms that appear when a fluid moves over a loose bed, such as subaqueous "dunes" on the beds of rivers and tidal estuaries and sand waves on the continental shelves beneath shallow seas (Hidayathulla and Karunaratna, 2013).

Jaffna lagoon of the northern Sri Lanka is surrounded by the densely populated Jaffna peninsula containing Palmyra palms, coconut plantations, and rice paddies. There are numerous fishing villages and some salt pans. The Jaffna lagoon is a shallow water body and has extensive mudflats, sea grass beds and some mangroves. The lagoon attracts a wide variety of wonderful aquatic creatures, animals and birds. Underground water quality of the coastal area of the lagoon is continuously degrading due to fishing related activities and dumping of garbage without proper management. The coastal area is widely used for the fishing purposes and for small scale production of salt. Unoccupied land scare used as points to dump garbage improperly. Most of the wells that are closer to sea are not used for public consumption because of the salty nature (Ranganathan Kapilan, 2015). It was decided to analyse its ground water so that some remedies for improvement could be possible and sampling locations (Gray, 1994). However there is no recent scientific water quality analysis conducted for the collector wells to determine the water quality and to identify the potential pollutants. Vallipuram area was selected as an ideal place of the above mentioned situation. Therefore this study was aimed at assessing the drinking water quality in the Vallipuram area of the northern Sri Lanka and to determine the suitability of the water for domestic utilization.

II. Materials and Methods

2.1 Study Area

This study was conducted in the Vallipuram costal area between May and September in 2015. Collector wells are located in the sand dunes. The location is rich in water and there are less hardness issues, less population density in the area so that anthropogenic activity is also very less.

2.2 Sampling method

Samples were collected randomly from four collector wells during the dry season between May and September in the year 2015. From each of the water sources samples were collected in two positions one from top and other from bottom and used for the analysis. Standard precautionary measures were adopted to minimize cross contamination of samples. Sterilized plastic containers and Durant bottles were used for collecting water from collector wells. This was done carefully to avoid contact between the containers and the walls of the wells, thus avoiding contamination of samples. Samples were labelled as Collector well 1, 2, 3 and 4. The samples were carefully transported and stored at low temperature in the laboratory refrigerators and later used for the physico-chemical analysis. Analysis was carried out based on SLS and APHA guidelines.

2.3 Design of sampler

The sampler was made of an iron cylinder of one litter capacity. The upper end of the cylinder was sealed but contained three holes through which the water can enter into the cylinder. A movable piston was set up inside the cylinder and connected with the upper part of the sampler. Two long running threads were tied each on the middle of the cylinder as well as the piston. The thread fixed to the piston was used to bring down the sampler to a desired depth. Once the sampler reached to a desired depth the thread fixed to the piston was released by tightening the other thread, which was fixed to the cylinder. After a few minutes again the thread fixed to the piston was tightened, while releasing the other and the sampler was taken out from the well (Health Canada, 2007).

2.4 Chemical and Physical analysis

The collector wells were operated at least ten minutes before the collection of the water samples. The water quality parameter estimation and calibration of equipments were done using standard methods and techniques (Trivedy and Goel, 1986). Water sample were analysed for pH (pH meter), electrical conductivity (EC meter), turbidity (turbid meter), total iron concentration (spectrometry), phosphate concentration (spectrometry), nitrate concentration (spectrometry), nitrite concentration (spectrometry) and colour based on Sri Lankan standards 614: part 1 (2013) and APHA method on field.

III. Result and Discussion

In the present investigation, two water samples were colourless and odourless, but water samples from collector well 2 was slightly reddish yellow and slight odour was also experienced. However it was suspected that the change in the colour of the water samples may be due to muddiness and the existence of ironic compounds. The variation in the temperature of water samples might have more effect directly or indirectly on all life processes.

pH is an indicator of the alkalinity or acidity of a water sample. In the Vallipuram area, the pH value ranged from 7.9 to 8.1. A pH range from 6.5 to 8.5 is desirable concentration as per guided by SLS. Therefore the pH of the water has no role of causing any severe health hazard. Water of study area is slightly alkaline in nature. The main sources of natural alkalinity are rocks, which contain compounds of carbonate, bicarbonate, hydroxide and phosphates (Hendershot et al., 1993, Tiimub et al., 2012). The value of alkalinity did not show significant variation among the collector wells in this study area. Alkalinity in itself is not harmful to human being, but in large quality, alkalinity imparts bitter taste to water and may cause eye irritation in human. The acidity may be due to excessive amount of carbon dioxide in the atmosphere, and this is an indication of accumulation of industrial wastes and agrochemicals (Goonetilleke et al., 2015). .

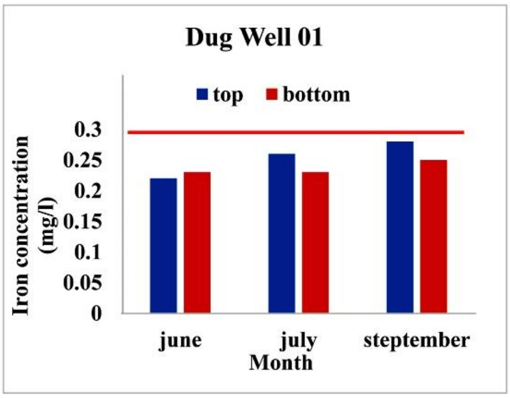
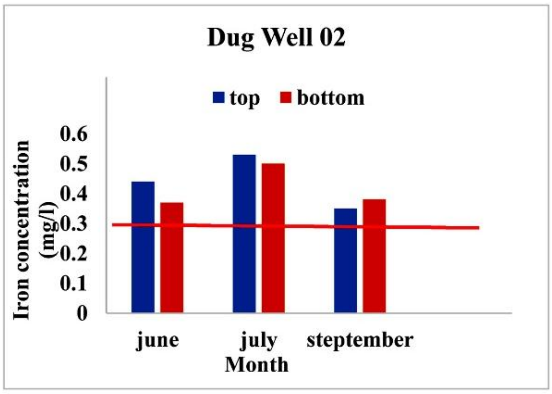


Figure1.1



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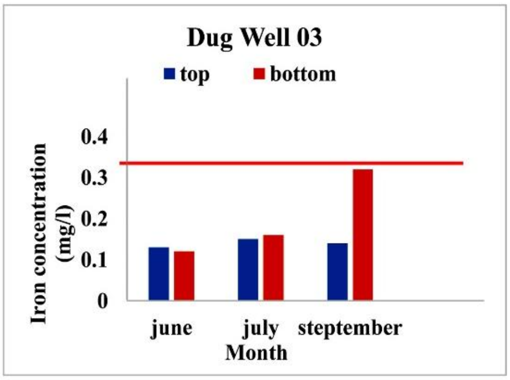

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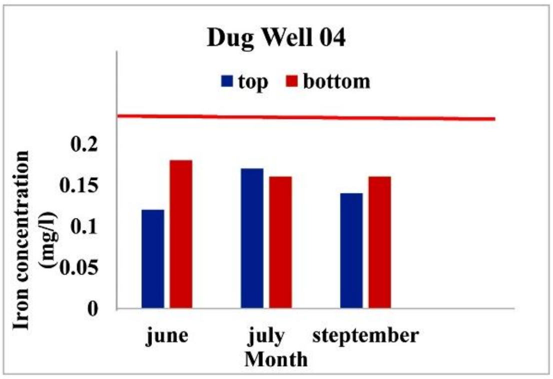

Figure1.4

Fig.1. Mean iron concentration at the top and bottom of the four different collector wells at Vallipuram area, Jaffna peninsula in three different months. The limited value of iron concentration in drinking water is 0.3mg/l (SLS 614:2013). It was indicated by red line mark in the graph.

Electrical conductivity estimates the amount of total dissolved salts or the total amount of dissolved ions in the water. In this study the electrical conductivity ranges from 379.2 to 1173.5 µS/cm and it is found to be within permissible range for the water sample collected from the collector well 1 only and not for the other samples (Moscow et al., 2011). The mean value of total hardness of the water samples tested is 285.5ppm with the standard deviation of ±179.65ppm which indicates that most water samples are hard except the sample from GW1 with total hardness 36ppm.This water sample is soft in terms of hardness.

Nitrates and nitrites are important parameters that impart a peculiar taste to water and reduce its chances to consume. Desirable limit of nitrate and nitrite are 50 and 3 mg/l (ICMR). The mean values of the nitrate and nitrite of the studied collector samples are 0.413 mg/l and 0.046 mg/l with the standard deviation of ±0.059 and 0.008. All the values obtained are much lower than the WHO and SLS accepted limit. Phosphate is an important quality parameter that affects the aesthetic property of water including taste and renders it unsuitable for drinking purpose if present in high concentration (Tiimub et al., 2012). The phosphate concentrations in study area ranged from 0.248 to 0.485 mg/l. The values the present study are on lower side considering WHO maximum limit of 2mg/l.

International Journal of Research and Innovations in Earth Science
Volume 2, Issue 6, ISSN (Online) : 2394-1375

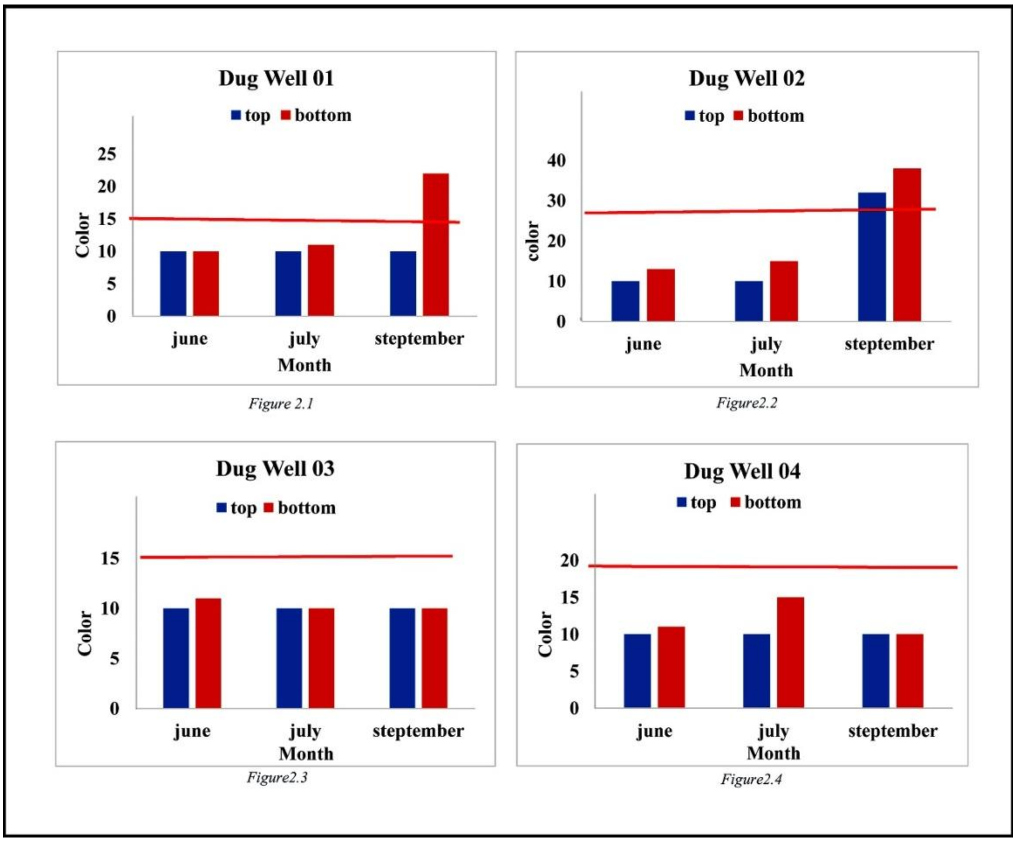

Fig.2. Mean values for colour index at the top and bottom of the four different collector wells at Vallipuram area, Jaffna peninsula in three different months. The limited value of colour in drinking water is 15 Hazen unit (SLS 614:2013). It is indicated by red line mark in the graph.

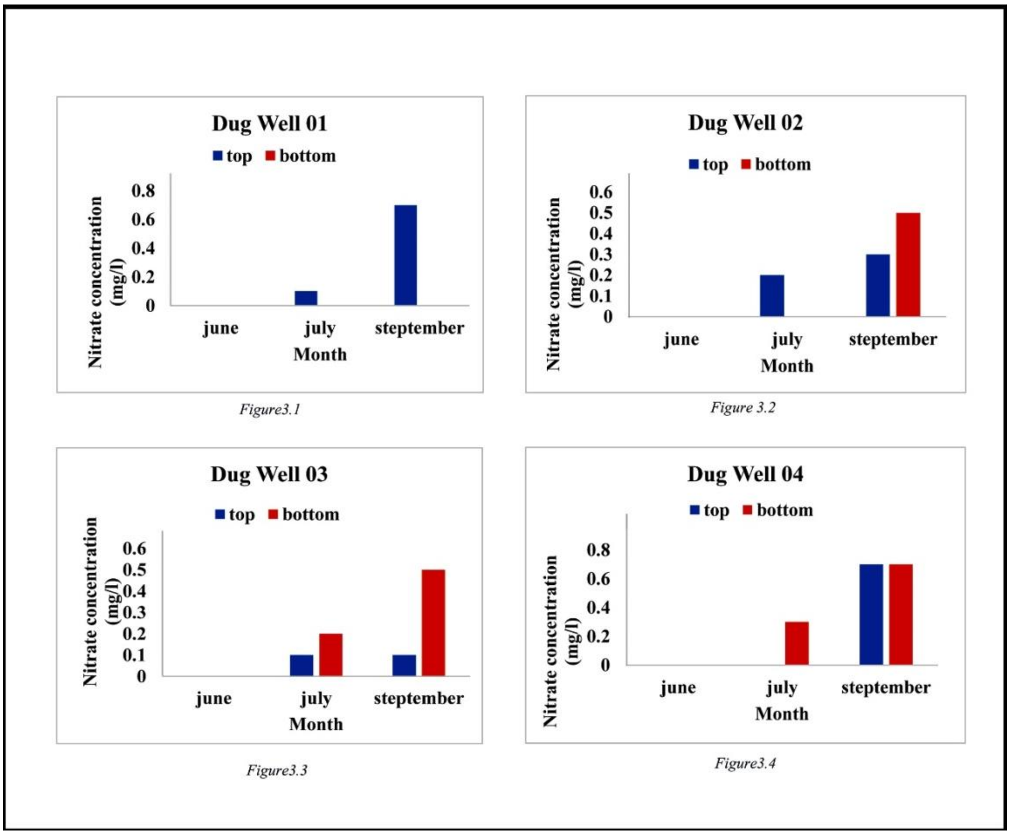

Fig.3. Mean values for nitrate concentration at the top and bottom of the four different collector wells at Vallipuram area, Jaffna peninsula in three different months. The limited value of nitrate concentration in drinking water is 50 mg/l (SLS 614:2013) and it is indicated by red line mark.

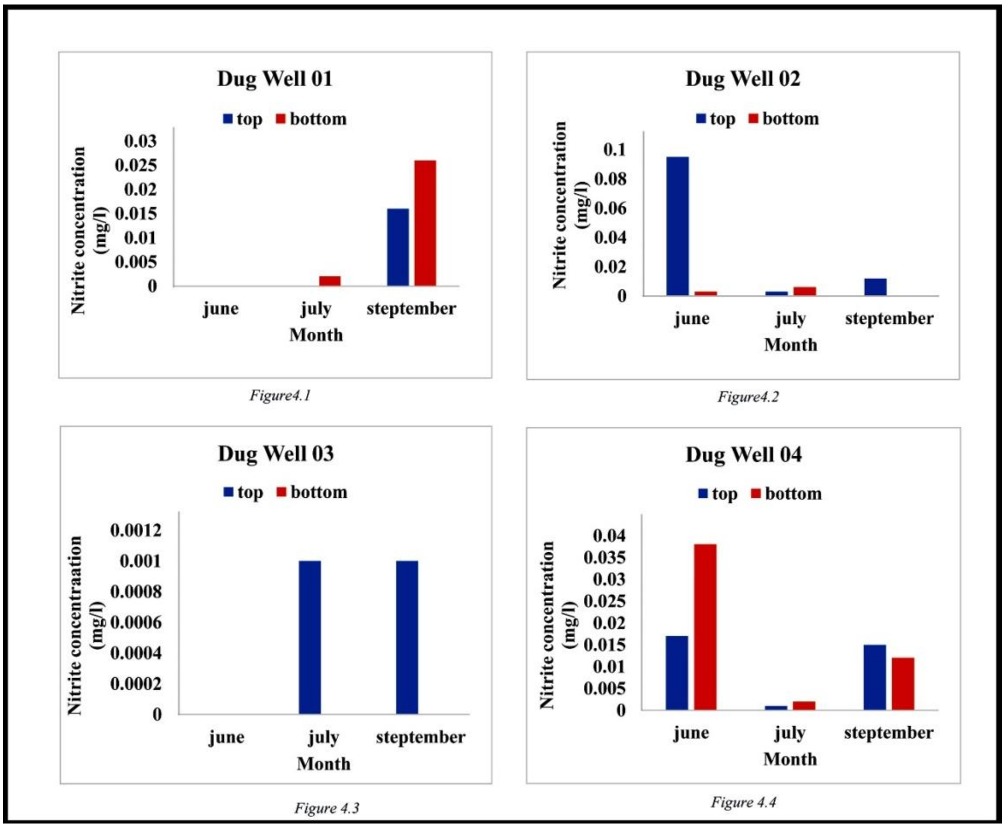

Fig.4. Mean values for nitrite concentration at the top and bottom of the four different collector wells at Vallipuram area, Jaffna peninsula in three different months. The limited value of nitrite concentration in drinking water is 3 mg/l (SLS 614:2013) and it is indicated by red line mark in the graph.

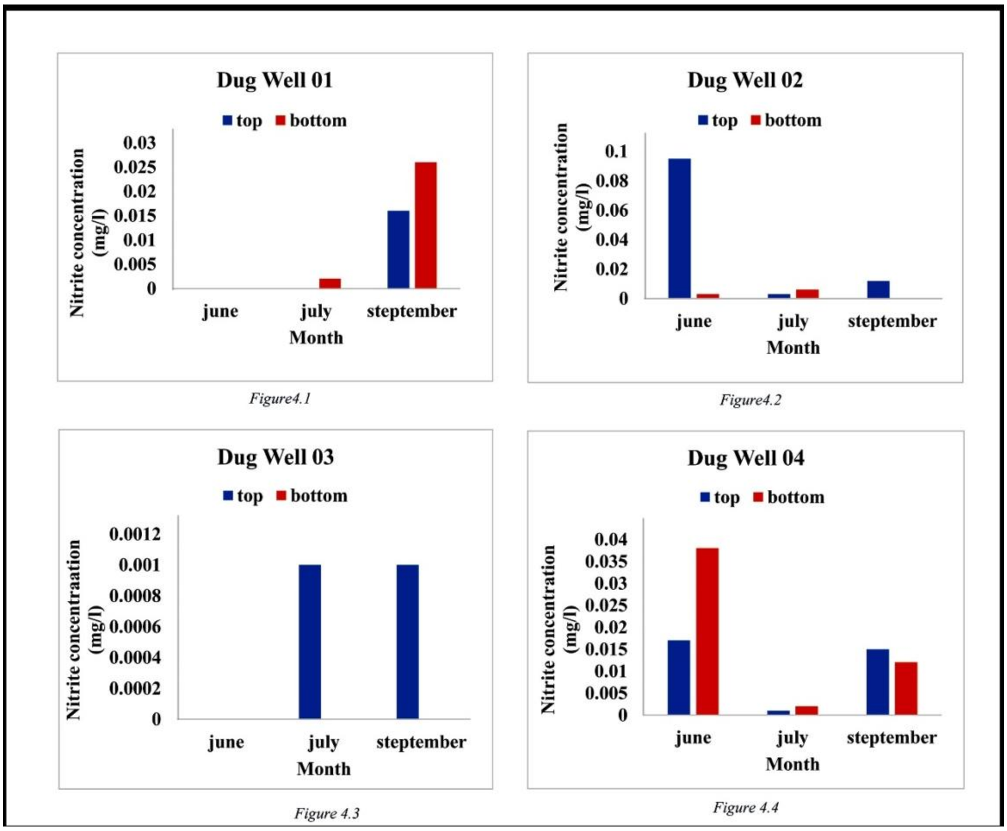

Fig.5. Mean values for Phosphate concentration at the top and bottom of the four different collector wells at Vallipuram area, Jaffna peninsula in three different months. The limited value of Phosphate concentration in drinking water is 2 mg/l (SLS 614:2013) and it is indicated by the red line mark in the graph.

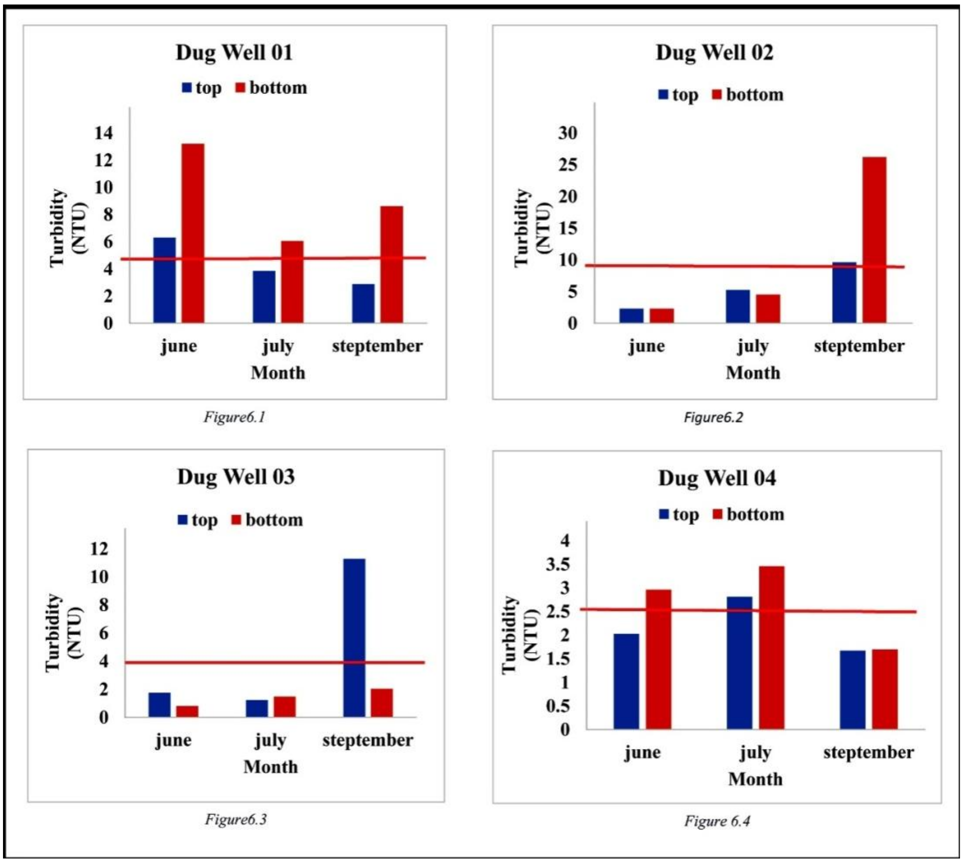

Fig.6. Mean values for turbidity index at the top and bottom of the four different collector wells at Vallipuram area, Jaffna peninsula in three different months. The limited value of Phosphate concentration in drinking water is 2 mg/l (SLS 614:2013) and it is indicated by the red line mark in the graph.

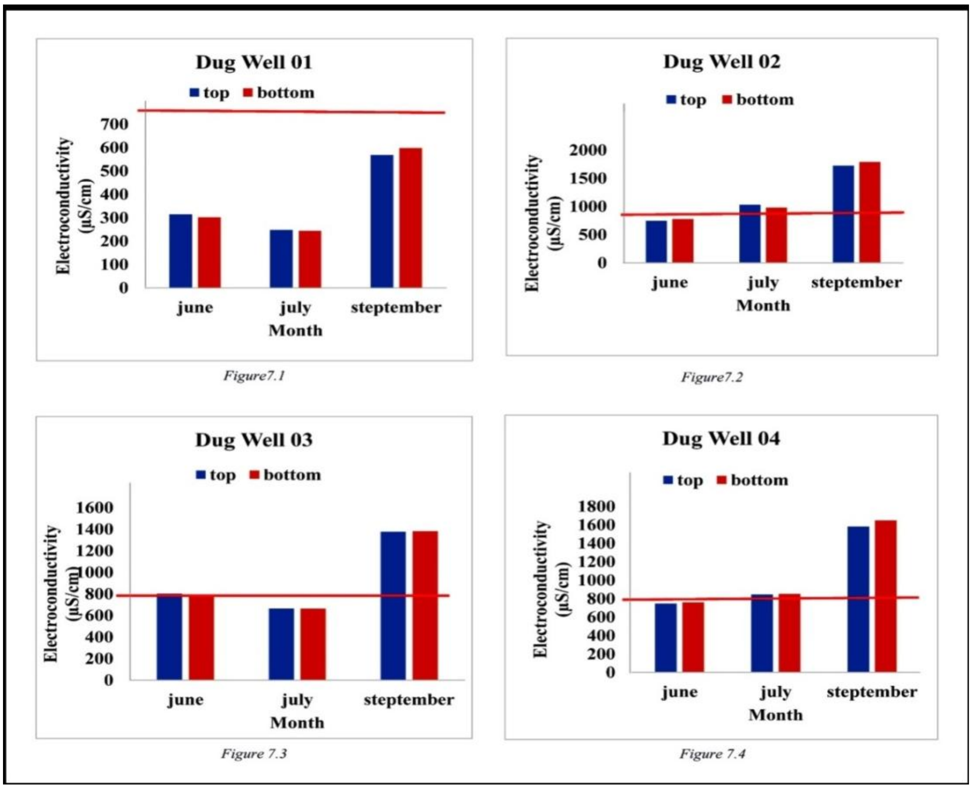

Fig.7. Mean values electro conductivity at the top and bottom of the four different collector wells at Vallipuram area, Jaffna peninsula in three different months. The limited value of Electro conductivity in drinking water is 750µS/cm (SLS 614:2013) and it is indicated by the red line mark in the graph.

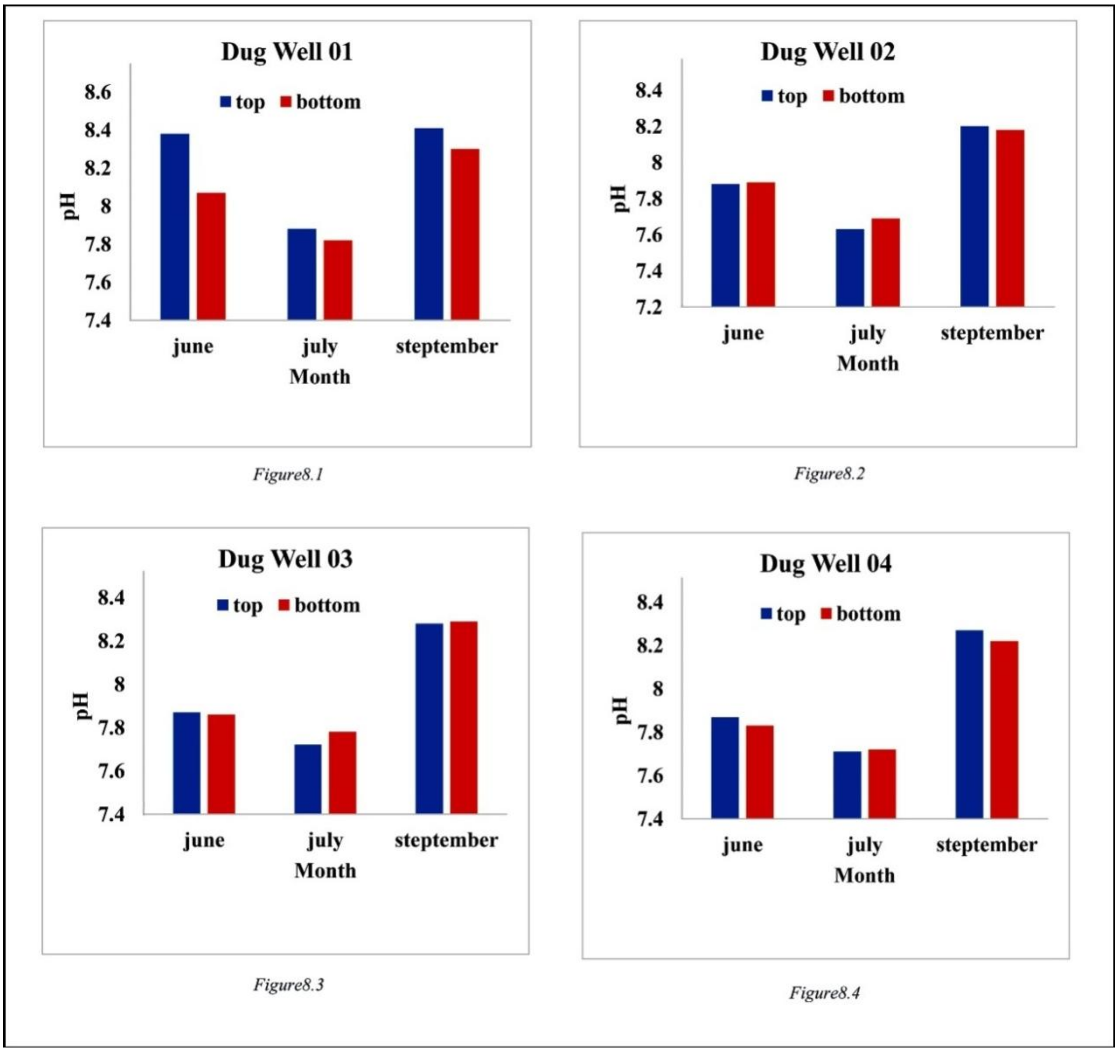

Fig.8. Mean pH values at the top and bottom of the four different collector wells at Vallipuram area, Jaffna peninsula in three different months. The limited value of pH in drinking water is 6.5 – 8.5 (SLS 614:2013) and it is indicated by red line mark in the graph.

Table 1: Physico-chemical parameters at different collector wells of Vallipuram area

S.No.	Parameters	Permissible Limits (SLS 614:2013)	Collector Well 01	Collector Well 02	Collector Well 03	Collector Well 04
1	Turbidity	2 NTU	6.813	10.223	5.286	4.223
2	Colour	15Hazen unit	12	19.167	10	10
3	Nitrate	50 mg/l	0.416	0.516	0.283	0.533
4	Nitrite	3 mg/l	0.157	0.020	0.000	0.014
5	Phosphate	2 mg/l	0.248	0.273	0.290	0.485
6	pH	6.5 – 8.5	8.1	7.9	8.0	7.9
7	Electro conductivity	750µS/cm	379.2	1173.5	947.3	1071.3
8	Iron	0.3mg/l	0.157	0.307	0.093	0.143

Amount of ironic salts is an important quality parameter that affects the basic property of water including taste and odour. The water would become unsuitable for drinking, if ironic substances are present in high concentration. The iron concentrations in the collector samples ranged from 0.093 to 0.307 mg/l. The value obtained in the well number 2 was higher than the maximum value (0.3mg/l) recommended by the WHO (WHO, 2004 and WHO, 2011). Iron is typically dissolved in water and when brought to the surface, can form “rust” which may settle out (Goonetilleke et al., 2015). Another source of iron is iron-reducing bacteria, which depend upon iron to live. These bacteria add iron to the water by attacking the piping of the system. Removing naturally-occurring iron in the water may require special water treatment equipment (Hamilton, 1985). Iron-reducing bacteria may be controlled or eliminated by adequate chlorination.

The most common water complaints are those of red water, laundry spotting, metallic tastes, and staining of plumbing fixtures. These are usually due to the presence of iron above 0.3 mg/l. The smells of most of the water of the collector well two is like irony. It may be due to the corrosion of iron pipes collecting water in the Vallipuram area. The shortage of iron causes a disease called "anaemia" and prolonged consumption of drinking water with high concentration of iron may be lead to liver disease called as haermosiderosis. Industrialization without proper waste management system and excessive applications of fertilizers and pesticides in agriculture are the two princile reasons of water pollution. Similar experiments has been performed worldwide to determine the water quality of diverse water sources (Kalwela and Savale, 2012, Kapilan, 2015 and Tiimub et al., 2012).

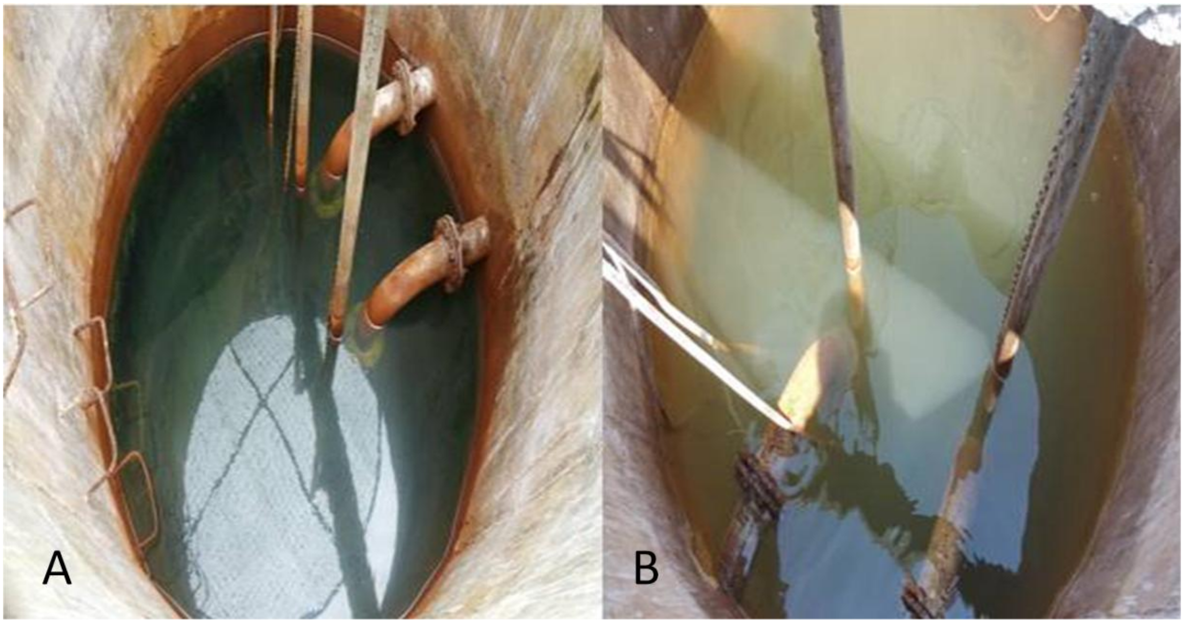

Fig.9. A – Well A that contains pure, drinking quality water. B – Well B that contains polluted water. The colour of the water is slightly reddish and gives a bad ironic odour.

This research is concerned primarily with the behaviour of iron in solution. Iron occurs in two oxidation states, the divalent or ferrous form and the trivalent or ferric form. Iron in aqueous solution is subject to hydrolysis. The iron hydroxides formed in these reactions. The ferric form, have very low solubility (Aiyesanmi et al., 2008). The retention of iron in solution is consequently affected by the pH of the solution. In most natural waters, the pH is not low enough to prevent hydroxides from forming, and under oxidizing conditions, practically all the iron is precipitated as ferric hydroxide (Perera et al., 2012). Irons have a tendency to form complex ions with inorganic and organic materials in solution state. These ions may be considerably more stable than the non complexed iron and more may remain in solution that might spoil the quality of the drinking water. The primary source of iron is the water bearing strata (Maddison and Gagnon, 1999, Perera et al., 2012). Corrosion of iron pipes in a water distribution system can cause three different types of problems. 1. The pipe mass is lost through oxidization to soluble iron species or iron-bearing scale. 2. The scale can accumulate as large tubercles that increase head loss and decrease water capacity. 3. There will be a release of soluble or particulate iron corrosion-by products into the good quality water. This will decrease the aesthetic quality of water and often leads to yellowish or reddish water at the tap. Therefore corrosion of iron pipes has become as a serious issue in the water industry.

IV. Conclusion

The analysis of water samples obtained from Vallipuram area of Northern Sri Lanka revealed that the samples obtained from the first, third and fourth collector wells do not contain any contaminants and the samples obtained from the second collector well contained iron as a contaminant. The quality of the water in the collector well two is not suitable for drinking but can be used for irrigation after the eradication of the iron and ironic compounds by appropriate treatment. The people in the area mainly depend the collector wells, for their essential water usage like drinking, home use and irrigation. This study reveals that all the values obtained are within the permissible limit in all levels of all the collector wells apart from the well 2, according to the WHO standard. Special care must be needed to control the fertilizers reaching the collector wells and is also essential to identify the pollutant/s existing in the water collector wells. After the eradication of the pollutant in the collector wells, a periodical analysis needs to be done to make sure there are no more contaminants in the drinking water sample.

Acknowledgement

The authors thank the funding and support provided by the staff of the Department of Botany, University of Jaffna and the National water supply and drainage Board, Jaffna, Sri Lanka.

International Journal of Research and Innovations in Earth Science
Volume 2, Issue 6, ISSN (Online) : 2394-1375

REFERENCES

[1] Agbalagba, OE, Ononugbo, CP and Alao AA. Investigation into the physico-chemical properties and hydrochemical processes of groundwater from commercial boreholes in Yenagoa, Bayelsa State, Nigeria, African Journal of Environmental Science and Technology, 2011, 5(7):473-481

[2] Ahlberg, E.. Surface Complexation. Proc. Internal Corrosion in Water Distribution Systems. Goteborg, Sweden, 1995. 147-155.

[3] Aiyesanmi, AF, Tomori, WB, Owolabi, BJ. Relative partitioning of some heavy metals in dumpsite soil using chemical speciation technique. Intern. J Chem. Sci, 2008. 1(1): 96 – 104.

[4] American public Health Association water Pollution Control board. APHA, AWWA-WPCF, Standard methods for examination of water and waste water, New York (USA), 1965, 6:74-92.

[5] APHA, Standard methods for the examination of water and wastewater (17th Edn) Washington,D.C, 1989.

[6] ATSDR. Health Concerns Related to Nitrate and Nitrite in Private Well Water. U.S.A. Department of Health and Human Services. Agency for Toxic Substances and Disease Registry. http://www.atsdr.cdc.gov/HAC/pha/reports/pacificgaselectric_04222003ca/pdf/apph.pdf Date accessed 08/08/2015, 2000.

[7] Boman BJ, Wilson PC, and Ontermaa EA. Understanding Water Quality Parameters for Citrus Irrigation and Drainage Systems. The Institute of Food and Agricultural Sciences (IFAS), University of Florida Extension Services. Circular No. 1406, 2012.

[8] De Silva, CS. and Weatherhead, K.. The use of large diameter wells for supplementary irrigation in the dry zone of Sri Lanka. Proc inter conference water down under No comprising 94, 2B, 595-599.

[9] Dissanayake, C.B., Senaratne, A. Paleogeographical reconstruction of Jaffna peninsula J. Geol. Soc India, 1981. 23: 369-377.

[10] Dhivyaa Pranava, TS, venkatesa Rao, T, punithavathi L, karumanithi, S and Bhaskaran, A.. Ground water pollution in the polar rever bed near vellore tamilnadu, India, *Indian J, Sci technol.* 2009. 4(11):19-21.

[11] EPA. Parameters of water quality: Interpretations and Standards. A publication of Ireland Environmental Protection Agency 2001.

[12] Goonetilleke, A., Thomas, E., Ginn, S. and Gilbert, D. Understanding the role of land use in urban storm water quality management. Journal of Environmental Management, 2015, 74 (01):31-42.

[13] Gray NF, Drinking Water Quality: Problems and Solutions, McGraw Hill, New York, 1994,118-130.

[14] Gulta DP, Sunita and Saharan JP. Physico chemical analysis of ground water of selected area of kaithal city (Haryana) India. Researcher, 2009, 1(2):1-5.

[15] Hamilton, W.A. Sulphate-Reducing Bacteria and Anaerobic Corrosion. Annual Review of Microbiology, 1985, 39:195.

[16] Health Canada, Environment and Workplace. Report on water quality. Copper. http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/copper-cuivre/ index-eng.php. 1992, Date accessed 07/08/2015

[17] Health Canada, Total, Fecal & E. coli Bacteria in Ground water, 2007. *WaterStewardship Informationseries.* http://www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/library/groundfactsheets/pdfs/coliform%28020715%29_fin2.pdf. Date accessed: 08/08/2015

[18] Herbert, R and Kitching, R. Determination of aquifer parameters from large diameter dug well pumping tests ground water. 1981, 19(6): 593-599.

[19] Hidayathulla, M.S.M. and Karunaratna, G.R.R. Assessment of Groundwater Quality in Shallow Aquifers in Jaffna Peninsula, Proceed. 29th Technical Sessions of Geological Society of Sri Lanka 2013:109-113.

[20] Jayalakshmi J, Lakshmi N, and Singara Charya MA, Assessment of Physico-Chemical Parameters of Water and Waste Waters in and Around Vijayawada. *International Journal of Research in Pharmaceutical and Biomedical Sciences.* 2011,2(3):1040- 1046.

[21] Kalwela, A.M and Savale, PA. Determination of Physico-Chemical Parameters of Deoli Bhorus Dam water Advances in Applied Science Research, 2012, 3 (1):273-279.

[22] Kapilan, R Determination of Drinking Quality of Water near the Coastal Areas of Jaffna Lagoon, Journal of progressive research in Biology, 2015, 2(1):32-36.

[23] Maddison, L.A. & Gagnon, G.A.. Evaluating Corrosion Control Strategies For A PilotScale Distribution System. Proc. AWWA Water Quality Technology Conference, Paper M14-5. Tampa, FL. 1999.

[24] Moscow, M., Jothivenkatachalam, K. and Subramani, P. Agricultural activities impact on groundwater of Cauvery River belt in Papanasam taluk, Tamilnadu, India, Der Chemica Sinica, 2011, 2(2):199-206.

[25] Perera, L., Perera, G. R. Y., Wattavidanage, J. and Nilakarawasam, N. Development of a Macroinvertebrate–based Index of Biotic Integrity (MIBI) for Colombo-Sri Jayewardenepura Canal System, Journal of Tropical Forestry and Environment, 2012, 2 (01): 10-19.

[26] Senaratne, A. and Dissanayake, C.B. Palaeogeographic Reconstruction of Jaffna Peninsula, Sri Lanka, Journal Geological Society of India, 1982: 23: 545-550.

[27] Sri Lankan Standards 614: part 1. Specification for potable water physical and chemical requirements. 1983:5-10.

[28] Tiimub BM, Kuffour RA, and Akwatia GA. Quality Determination of Groundwater for Drinking at Nkawkaw in the Eastern Region of Ghana, *Civil and Environmental Research*, 1982:2, No.9.

[29] Trivedy, R. K and Goel, P. K.. Chemical and Biological Methods for Water Pollution Studies, Environmental Publication, Karad, India. 1986.

[30] USEPA. The Water Cycle and Water Conservation. http://www.epa.gov/region1/students/pdfs/gndw_712.pdf. Date accessed: 16/5/2015

[31] Weiner ER, Application of Environmental Chemistry: A Practical Guide for Environmental Professionals. Lewis Publishers Washington.2000.

[32] Wijesekera, J., Senaratne, A. and Gunatilake, A.A.J.K.. Land gain in northern Sri Lanka, Proceed. Auto Carto 2012 - Columbus, Ohio, USA - September 2012.16-18.

[33] WHO. International standards of drinking water, world health organization, Geneva, 2004, 55-79.

[34] WHO. Manganese in drinking water. Background document for development of WHO Guidelines for Drinking-water Quality, 2011.

[35] World Health Organization (WHO). Guidelines for Drinking-Water Quality. Third Ed. 2003, Geneva, /http://www.who.int/water_sanitation_health/S.

[36] World Health Organization (WHO), International standards of drinking water, World health organization, Geneva 2004, 55-79.

[37] World Health Organization. Guidelines for drinking water quality 1: Recommendations. Geneva. 79.

[38] Yadav SS, and Kumar Rajesh, *Ultra Chemistry*, Pelagia Research Library, Advances in Applied Science Research, 2011, 2(2):197-201.

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