International Journal of Research in Social Sciences
Vol. 9 Issue 8, August 2019,
ISSN: 2249-2496 Impact Factor: 7.081
Journal Homepage: http://www.ijmra.us, Email: editorijmie@gmail.com
Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gage as well as in Cabell's Directories of Publishing Opportunities, U.S.A

Emancipation of Effluent from Fertilizers and Chemical Pesticides Causing Water Contamination at Rishipur Village, West Bengal, India

Dr. Lovely Sarkar

Abstract

The numerous uses of chemical pesticides have got amplified to a great extent with the instigation of the green revolution which resulting in enormous increase in the crop production which eventually builds the economy of an area. This progression of contemporary cultivation has led to filthy stipulation of nearby water bodies. The present paper deals with the water contamination occurring due to frequent application of inorganic fertilizers, agrochemicals and chemical pesticides at agriculture based Rishipur village of West Bengal, India. The filthy condition of the water was observed more deteriorated after a definite time of applying chemical pesticides in the agricultural field. The consequence of pesticides effluence in water has been discussed in this paper. For comparative study, the physico-chemical characteristics of water of nearby wetland of the agricultural field and water drawn from hand pump, various physico-chemical parameters viz. pH, conductivity, TDS, concentration of Cl^-, SO_4^{-2}, CO_3^{-2}, HCO_3^-, Ca^{+2}, Mg^{+2}, DO, BOD, COD have been studied in the month of November, 2018. The present study signifies that the contemporary agricultural practice can cause severe environmental destruction in the long term.

Key words:

Wet land, Water, pesticides, Physico-Chemical characteristics, Contamination

Author correspondence:

Dr. Lovely Sarkar
Assistant Professor, Department of Chemistry, Siliguri College, West Bengal.
Email: lovely.sarkar@rediffmail.com

1. Introduction

The sediments of fertilizers and chemical pesticides which are used in cultivation land may get introduced to the nearby water bodies like wet lands, lakes, ponds etc. by leaching process, through rain or irrigation. About 70% of the chemical pesticides applied for cultivation, get in touch with adjacent water bodies in the course of rainfall, irrigation [1] or by means of their direct use in the water bodies as because to manage aquatic weeds [2]. For the bumper crop production the agricultural workers are now a days apply various chemicals or inorganic fertilizers and chemical pesticides to control weeds, insects etc. different chemical pesticides are used enormously. All over the world in agriculture around 2.5 million tons of pesticides are being used annually [3]. In India the residues of pesticides in soft drinks and bottled water has raised consciousness over water pollution with chemical pesticide residues [4]. It is alarming that the presence of chemical pesticides has been proved in approximately the entire foodstuffs as Hexachlorobenzene (HCB) a fungicide was identified in water, human milk and human fat samples which was collected from Faridabad and Delhi [5]. These days environmental pollution of natural water bodies by chemical pesticide residues is of enormous apprehension as depicted by Kolpin et al.[6]. Also there are many precise conclusions confirming the ailing effects of chemical pesticide revelation on human beings [7]. At present the urban people are more aware of the ailing effects of inorganic fertilizers and pesticides as these are not degraded easily and accumulate in the soil and water for a long term. However, recently so many research papers are being published about the ill effects of fertilizers and pesticides on air, soil, water and health. Rekha and Naik depicted that recuperating from the jubilation of green revolution; India is now fighting from residual belongings of expansively used chemical pesticides such as DDT, HCH, Endosulfan etc. and promoting for organic farming [8]. People are becoming aware of the detrimental effect of the chemicals which ultimately pollute the vegetation and utmost the human health. The growing facts of brain disorder and various other acute incessant diseases in present era are also caused by the unpleasant consequence of pesticides [9]. It was reported that in Kerala about fifty thousand children are presently affected by various cancers due to the use of deadly pesticides which are already prohibited in different countries [10]. Consequently, concern over chemical pesticides and fertilizers used in agricultural fields has been ever-increasing issue at present. According to WHO estimate every year 3 million cases of acute pesticide poisoning occur globally [11]. Thus it's a matter of one type of contamination taken as a whole. Overall worldwide chemical contamination has been a matter of immense concern with increase in public awareness towards environmental tribulations [12].

It is renowned that in India, a bulk fraction of the chemical pesticides used on agricultural land arrives at the oceans through atmospheric transport and river emancipation [13]. Also groundwater contamination due to chemical pesticides is a universal problem [13]. The chemicals can get in touch with water systems through industrial wastes, used manures, pesticides, house hold wastes etc. One survey in India reported that Organo Chlorine pesticides above the *EPA* standards are present in about 58 % of drinking water samples collected from different hand pumps and wells around Bhopal [14]. Direct and unprotected practice of using chemical pesticides can cause lethal diseases. It is observed that pesticides are carcinogenic and mutagenic in nature [15]. The hazardous application of chemical pesticides has been accounted to augment revelation levels, by this means raising the danger of undesirable health effects among exposed individuals [16]. Pesticides are those chemicals (such as insecticides, fungicides, herbicides, rodenticides, molluscicides, nema- tocides, plant growth etc.), which have been widely used throughout the world to increase crop yield and to kill the insect-pests responsible for transmitting various diseases to humans and animals. However, according to several reports, these chemicals have been proved to inflict adverse impacts on the health of living beings and their environment [17-20]. In most of the technologically advanced countries, organochlorine (OC) insecticides, which were used successfully in controlling a number of diseases such as malaria and typhus, have been banned or restricted. After 1960, other synthetic insecticides such as organophosphate (OP), carbamates, pyrethroids, and herbicides and fungicides were introduced into agricultural practices as well as several health management programmes. Pesticides are commonly found in water. The ground-water from some US and Canadian provinces has been reported to contain the residues of 39 pesticides and their metabolites [21]. The calculation of level of allowable pesticide for water is made depending on the exposure of children and adults exposure; the children being 4 times more vulnerable to the pesticide toxicity than adults [22]. UNEP linked the effects of pesticides to "the level of oncological (cancer), pulmonary and haematological morbidity, as well as on inborn deformities and immune system deficiencies" [23]. In the studied area the agricultural workers use mainly ammonium sulphate nitrate, urea, ammonium chloride, ammonium phosphate, NPK complex fertilizers etc. and the most common pesticides the farmers use are Elathion (Ethion -40% + Cypermethrin - 5% E.C.), Phorachem (Phorate 10%), White Nignamycin 10%, Rephate 95, Tromaxx (Chloropyriphos 20%), Brammhastra (Chloropyriphos 50 % + Cyphermethrin

5 %) etc. Most common crop in the area is paddy and mostly the paddy plantation is done during December in the studied village and the fertilizers are generally applied before ploughing, after plantation and before blooming, on the other hand chemical pesticides are applied during the end of February to first week of January. The present study was done at the middle of November, 2017. Till now no such comparative study has been done taking the water samples from different sources in a same area. Therefore, the analysis may help to aware the local people in the studied village about the destructive agricultural practices so that it may have a great impact on the future generation too.

2. Research Method

2.1. Study area

Rishipur Village is located at Habibpur Block in Malda District of West Bengal, India. It is situated about 15 KM towards east from district head quarters- English Bazar. Main economy of this village depends on agriculture. Paddy is the most common cultivation commodities production in this village. Different fertilizers are applied to the field for the high yielding crop production. Chemical pesticides are mostly applied to the plant at the flowering and grain filling stages particularly milk stages, also in some cases prior to bloom to petal fall. No drainage facility is accessible in this village. The long term effect of such fertilizers and chemical pesticides used for the betterment of crop production finally get in touch with the nearby water bodies resulting in all-embracing effluence creating hazards to the human beings, the aquatic existence and the environment too.

2.2. Materials and Methods

All the chemicals used to determine the physical characteristics of water were of analytical grade. Deionised distilled water was used for the study. To collect water samples Amber glass bottles along with polypropylene cap were used. For analysis of water quality the water samples (W_H, W_S) were collected from a hand pump placed in the dwelling area and from the surface water of a wet land attached to a cultivable land about 130 meter away from dwelling area and where the main crop produced is paddy. All necessary chemicals used for the determination of the physico-chemical characteristics of the water samples were of Merck and S.D Fine. Temperature was determined by using Digital thermometer. pH of water samples was measured by digital pH meter. The conductance was measured by digital conductivity cell as illustrated by Arbind Kumar and Seema, 2016, [24]. TDS was measured by water testing kit. EDTA titration method was applied to examine the concentration of Calcium (Ca^{+2}) and Magnesium (Mg^{+2}) ions present in water samples, as depicted by (Lanyon and Heald, 1982), [25]. To measure BOD in water samples BOD Track Apparatus, HACH, USA [26] and COD present in water was determined by usual titration method following standard methods. Determination of anions- Chloride (Cl^-), carbonate (CO_3^{-2}) and bicarbonate (HCO_3^-) were done by chemical titration method [27]. Sulphate (SO_4^{-2}) ions present in water was measured by gravimetric method [28]. All the experiments were repeated twice.

3. Results and Analysis

Physico-chemical constraints provide important information concerning the extent of effluence in the water bodies. The sediments of non bio degradable fertilizers and chemical pesticides used for cultivation in the farming lands, in general, discharge through rain, irrigation, leaching process or sometimes direct tumbling which ultimately enter the close by water bodies causing widespread contamination. The studied physico-chemical characteristics mainly reveal the extent of toxic waste. All the experimental data are represented in Table 1.

3.1. Temperature

Temperature of any water body can help to recognize the heat content of the system. Warm water holds lesser amount of oxygen in comparison to cold water. Heat of the Sun, cutting down the trees around the wet land often raises the temperature of water. At present it is also very important and most debated issue that frequent use of chemical pesticides along with chemical fertilizers may cause the increase in average temperature of any nearby water body of the agricultural lands. The present study shows that the temperature of the water under study varies from 23.4 to 24.2 ^{0}C. Warm water also leads to poorer level of oxygen dissolved. When soil washes into the water it becomes turbid and darker, that detains more heat than that of clear water. Often green water carrying algae is warmer than clear water [29].

3.2. pH

The pH value indicates the activity of hydrogen ion present in the water. The concentration of carbon dioxide, carbonates and bicarbonates present in the water under experiment resolute the pH of the system. It can cause augmentation of pH standards to different intensity depending on their solubility, temperature and pressure as well. In my study, it is observed that, the least value of pH is 5.8 for water sample W_S and maximum value is 6.2 for sample W_H whereas according to BIS, 2009 the tolerable perimeter of pH is 6.5-8.5 for the environment. Thus it can be depicted that the value of pH signifies acidic character which is not at satisfactory level. The aquatic living beings acclimatize to a definite pH level and may depart their life due to slight changes of pH of the water. This pH variation between the two water samples is shown in the figure 2.

3.3. Electrical Conductivity

Electrical Conductivity is capability of carrying current due to the existence of inorganic dissolved components

like different anions –sulphate (SO_4^{-2}), chloride (Cl^-), carbonates (CO_3^{-2}), bicarbonates (HCO_3^-) etc. and cations –calcium (Ca^{+2}), magnesium (Mg^{+2}) etc. those are accountable for conducting electricity. Temperature has also a great impact on conductivity as conductivity increases with rising temperature. A definite amount of manure would elevate the conductivity due to the presence of various ions in the water system. Range of conductivity preferred for irrigation water should be less than 250µmho/cm [30]. The electrical conductivity is also affected by the suspended impurities and the concentration of cations and anions present in the water under study. The amount of EC % can also increase upto 2 or 3 % with increase in temperature of 1^0C [31]. The tolerable limit of the electrical conductivity as in water as proposed by BIS 2009 is 750 µS/cm. In my study the electrical conductivity of the water is ranging between 143 – 312 µmho/cm at 25°C. For both the different samples, the values of conductivity fell within the safety values but for the sample W_S the water is not suitable for irrigation.

3.4. Total Dissolved Solids

Total dissolved solids indicate presence of minerals, inorganic salts, some amount of organic matter metals, ions (cations or anions) dissolved in water system. So TDS means the total amount of inorganic salts (Ca^{+2}, Mg^{+2}, K^+, Na^+, HCO_3^-, CO_3^{-2}, SO_4^{-2} etc.) and some amount of organic matter dissolved in water. Subsequently common water excellence can be realized by this parameter. The unbearable limit of TDS can be poisonous to aquatic existence which may raise the concentration of ions or alter the water composition. Most of the aquatic ecological units concerning varied fish fauna can be proficient to accept TDS intensity upto 1000 mg/l [32]. The present study shows that the average value of TDS varies from 44.7 to 239.4 and uppermost value is conceded by water sample W_S which is within maximum limit.

3.5. Chloride

The concentration of chloride anions is one of the most important components for cultivation. Chloride is poisonous to vegetation and is unwanted to steel boilers due to hastening of decay by other reasons [33]. The approval perimeter for Cl^- is 250 mg/l for BIS, 2009. In the study sample, Chloride ions have comprised of the utmost of instinctive water bodies that may approach as effluence across fertilizers or chemical pesticides. The least value of chloride ions is 58 mg/l and utmost 299.8 mg/l in our study.

3.6. Sulphate

Presence of sulphate anions in water bodies may be due to oxidation of sulphide substances. Generally sulphate is found in small amount in ground water. The tolerable limit of sulphate ion concentration is 200 mg/l according to BIS, 2009. Sulfate effluence can be the consequence of atmospheric deposition, chemical fertilizers, and oxidation of pyrite deposits in the deeper subsoil [34,35]. Here in the table 1, the SO_4^{-2} ion concentration shown varies from 47.3 mg/l for W_H to 270 mg/l for W_S. Subsequently sulphate ion concentration is not suitable for wet land surface water.

3.7. Alkalinity

Bicarbonate and Carbonate anions are mainly crucial elements of water. From the macrobiotic decay of soil, CO_2 is generated which is the main component from which bicarbonate and carbonate ions are formed. These ions confirm the alkaline behavior of a system. The experiment shows that the maximum quantity of bicarbonate is found 83.3 mg/l and lowest 43.9 mg/l. Whereas, the concentration of carbonate ions lies between 66.8 mg/l to 92.4 mg/l. Alkalinity is an important parameter used in corrosion control and helps in evaluating the buffering capacity of waste waters too. Here in this case alkalinity considered within WHO's acceptable border.

3.8. Hardness

In essence in each usual case the amount of Mg^{+2} and Ca^{+2} cations always sustain a balance state. If the water is Na^+ cation conquered and extremely saline then Ca^{+2} and Mg^{+2} do not perform uniformly in the organism and soil configuration deteriorates Water having hardness value more than 300 mg/l is undesirable for dying and textile industries and also for high temperature boilers [33]. Here Ca^{+2} is comparatively leading cation with the value varies between 18 mg/l to 193 mg/l in water. BIS 2009 fixed its tolerable border lower than 75 mg/l which is followed by the water sample studied. The suitable limit of Mg^{+2} ion concentration in water is 30 mg/l according to BIS, 2009. In our study the value of Mg reclines between 4.4 and 84 mg/l.

3.9. Dissolved Oxygen

Dissolved Oxygen is one of the significant constraints for evaluating water excellence and replicates the overall physical and chemical processes in water body and also is indispensable for aquatic living organisms. Insufficient amount of dissolved oxygen creates awful smell to water because of anaerobic disintegration of macrobiotic matters in water signifying contamination in the water. DO in our study ranges from 8.4 to 6.9 mg/l. It is observed that when the DO is high the pollution is low when the DO is low, the pollution level is high [36].

3.10. Biological Oxygen Demand

BOD is found to be more perceptive regarding organic matters contamination. According to the Royal Commission of sewage disposal, water containing BOD more than 5 mg/l is hazardous for household works. The BOD of water sample in our study varies from 4.1 to 8.4 mg/l which is just at the boundary line of the approved perimeter. BOD range in our study is very high representing ample existence of organic substances that is detrimental to the environment. Water with BOD level <4mg/l are considered as clean,

whilst those >10 mg/l are regarded as polluted and hazardous [37].

3.11. Chemical Oxygen Demand

The assessment of water quality regarding COD is of immense significance for water having adverse environment for the growth of bacteria, microbes, germs and various other living creatures. Existence of poisonous chemicals like inorganic pesticides also affects COD content of water. The WHO'S bearable edge for COD is 10 mg/l. Our water samples are perilous for living organisms as because least amount of COD is 6.3 mg/l and utmost 16 mg/l. The elevated value of COD points toward the existence of some suspended organic composites or else oxidisable inorganic materials.

Therefore, the study reveals that more or less the physico-chemical parameters are in desirable limit regarding water sample W_H while for wet land surface water, majority of the physico-chemical parameters are not within desirable maximum limit. Further, the physico-chemical characteristics of water drawn from hand pump presents comparatively lower values than that of wet land. The greater values of the surface water of wet land indicate obvious contamination of fertilizers and chemical pesticides. These data are represented in Table 1 and the variations of the values are demonstrated through the Figure 1 where the comparative study can be better illustrated by the graphical representation.

4. CONCLUSION

Emancipation of profoundly contaminated industrial effluents is undeniably causing hazards to the environment as well as human health. The present investigation can help to realize the effect of frequent use of agrochemical and chemical pesticides on water bodies. The outcome of our study is to make aware of using pesticides for cultivation, on the other hand to maintain the physical condition and efficiency of natural resources on which the mass of Indian villagers depend. These may be controlled through proper awareness, regulated knowledge about hazardous effect of chemicals on farming lands and water of nearby wetlands, methodical discharge of industrial wastes into water systems etc. The present circumstances can be the reason of irretrievable ecological, biological as well as environmental destruction in the long term in the name of temporary financial affluence by the bumper crop production using inorganic fertilizers and chemical pesticides. Chemical pesticides have infected nearly each fraction of our surroundings as pesticide remainders are found in soil and in exterior and ground water. The upshot of the present study can be capable of widening a water excellence consciousness and prevent the detrimental effect of the chemicals applied to the agricultural land. Any minuscule transformation in water, physico-chemical characteristics may unfavorably influence the biological mechanisms of entire ecological unit.

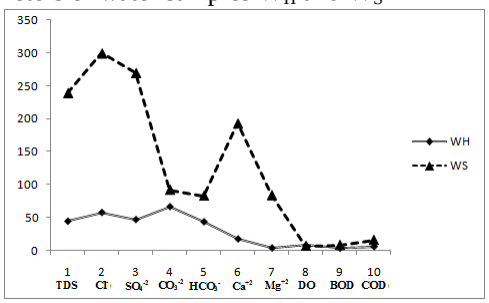
Acknowledgement:

The author is immensely grateful to Dr. M.N. Roy, Professor of Chemistry, North Bengal University for his enormous support from all around. She is also thankful to Dr.Sujit Ghosh, Principal of Siliguri College to carry out the study efficiently.

Table 1. Physico-chemical properties of the water samples (W_H=water drawn from hand pump, W_S= surface water of wet land)

Physico-chemical properties	Water sample- W_H	Water sample- W_S
Temperature (^{0}C)	23.4	24.2
pH	6.7	5.8
Electrical Conductivity (μmho/cm)	143	312
TDS (mg/l)	44.7	239.4
Cl^- (mg/l)	58.0	299.8
SO_4^{-2} (mg/l)	47.3	270.0
CO_3^{-2} (mg/l)	66.8	92.4
HCO_3^- (mg/l)	43.9	83.3
Ca^{+2} (mg/l)	18.0	193.0
Mg^{+2} (mg/l)	4.4	84.0
DO (mg/l)	8.4	6.9
BOD (mg/l)	4.1	8.4
COD (mg/l)	6.3	16.0

Figure 1: Graphical representation of physico-chemical parameters of water samples W_H and W_S



References

[1] Ridgway, R. L., Finney, J.C., McGregor, N.J. "Pesticide use in agriculture," *Environmental Health Perspectives*, vol. 27, pp. 103–112, 1978.

[2] Li, M., "Pollution in nation's estuaries: origination from the agricultural use of pesticides. In: Estuarine pollution control and assessment," *Proceedings of a conference*, office of water planning and standards, Washington, DC, 1975, pp. 451–466.

[3] Meena, R. P., Meena, S.S. and Meena, S.R., "Use of agrochemicals in agriculture, their consequences and

possible solution," *Green farming*, vol. 1 (4), pp. 54-55, 2008.

[4] Ramanjaneeyulu, D. and Chennamaneni, R., "Pesticides, Residues and Regulation: A case study of vegetables in Hyderabad Market," *Research Report 10:* Sustainable Hyderabad project, HUB, 2008.

[5] Nair, A. and Pillai, M. K. K., "Monitoring of hexachlorobenzene residues in Delhi and Faridabad, India," *Bulletin of Environmental Contamination and Toxicology*,vol. 42 (5), pp. 682-686, 1989.

[6] Kolpin, D. W., Thurman, E. W. and Linhart, S. M., "The environmental occurrence of herbicides: the importance of degradates in ground water," *Bulletin of Environmental Contamination Toxicology*, vol. 35, pp. 385–390, 1998.

[7] McCauley, L. A., Anger, W.K., Keife, M., Langley, R., Robson, M.G. and Rohlman, D., "Studying health outcomes in farm worker populations exposed to pesticides," *Environmental Health Perspectives*, vol. 114, pp. 953–960, 2006.

[8] Rekha, S. N. and Naik, R. P., "Pesticide residue in organic and conventional food–risk analysis," *Chemical Health Safety*, vol. 13, pp. 12–19, 2006.

[9] Abdollahi, M., Ranjbar, A., Shadnia, S., Nikfar, S., and Rezaie, A., "Pesticides and oxidative stress: a review," *Medical Science Monitor: International Medical Journal of Experimental and Clinical Research*, vol. 10(6), pp. 141-147, 2004.

[10] Laxmi, P., "Toxic chemicals trigger cancer in children: Green activists," *The Times of India*. Trivanantpuram. 14 Nov. 2016.

[11] Mittal, S., Kaur, G., and Vishwakarma, G. S., Effects of environmental pesticides on the health of rural communities in the Malwa Region of Punjab, India: A Review, *Human and Ecological Risk Assessment*, vol. 20(2), pp. 366–387, (2014).

[12] Mathivanan, V., Kayalvizhi, A. and Selvisabhanayakam, "An assessment of Physico-chemical parameters of fish culture ponds at Viswanathapuram, Cuddalore District, Tamilnadu," *Journal of current sciences*, vol. 7(1), pp. 253–258, 2005.

[13] "The atmospheric input of trace species to the world ocean," *Reports and Studies*, GESAMP, vol. 38, pp. 111, 1989.

[14] Kole, R. K., Bagchi, M. M., "Pesticide residues in the aquatic environment and their possible ecological hazards," *The Journal of Inland Fisheries Society of India*, vol. 27(2), pp. 79-89, 1995.

[15] Sahinkaya,S. C. Karatas, O. M., "Use of Fentons Reagents for Removal of Pesticides from Industrial Wastewater, Modern Management of Mine Producing," *Geology and Environmental Protection*, SGEM-2007, Bulgaria, 1 (2007), pp. 421-434.

[16] Koureas, M., Tsakalof, A., Tzatzarakis, M., Vakonaki, E., Tsatsakis, A. and Hadjichristodoulou, C., "Biomonitoring of organophosphate exposure of pesticide sprayers and comparison of exposure levels with other population groups in Thessaly (Greece)," *Occupational* and *Environmental Medicine*, vol. 71, pp. 126–133, 2014.

[17] Igbedioh, S. O. "Effects of Agricultural Pesticides on Humans, Animals and Higher Plants in Developing Countries," *Archives of Environmental Health*, Vol. 46, pp. 218-223, 1991.

[18] Jeyaratnam, J., "Health Problems of Pesticide Usage in the Third World," *British Medical Journal*, Vol. 42, pp. 505-506, 1985.

[19] Saiyed, H. N., Bhatnagar, V. K. and Kashyap, R., "Impact of Pesticide Use in India," *Electronic Journals: Asia Pacific Newsletter*: 1999-2003.

[20] Karunakaran, C. O., "The Kerala Food Poisoning," *Journal of Indian Medical Associtaion*, Vol. 31, pp. 204-207, 1958.

[21] Hallberg, G. R., "Pesticide Pollution of Groundwater in the Humid United States," *Agrigulture, Ecosystem and Environment*, Vol. 26, (3-4), pp. 299- 367, 1989.

[22] McConnell, *et al.* "Health Hazard Evaluation Report in Pesticides in the Diets of Infants and Children," *Pesticides in the Diets of Infants and Children*, National Academy Press, Washington, D.C., 1993.

[23] United Nations Environment Programme, "The Aral Sea: Diagnostic Study for the Development of an Action Plan for the Conservation of the Aral Sea," Nairobi, 1993.

[24] Kumar, A. and Seema., "Soil Fertility Status in and Around the Tea-Garden Belt of Belwa, Kishanganj District, Bihar, India," *International Journal* of *Plant* & Soil Science, vol. 11(2), pp. 1-14, 2016.

[25] Lanyon, L. E. and Heald, W.R. Magnesium, calcium, strontium and barium. Agronomy No. 9, 2nd edition, American Society of Agronomy, Madison, WI. pp. 247-262, 1982.

[26] Standard methods for the examination of water and waste water, ALPHA, American Public Health Association. USA. 19th edition, 1992.

[27] Official and tentative methods of analysis of the association of official agricultural chemists. A.O.A.C. (7th edn.), Washington. pp. 910, 1950.

[28] Richards, L.A., Diagnosis and improvement of saline and alkali soil. U.S. Salinity Lab. Staff. USDA Handbook 60. Washington D.C. US. 1954.

[29] Earth Force "Water Quality Parameters" http://www.eeweek.org/assets/files/water%20Quality%20Testing/Water %20Quality%20Parameters.pdf. July 15, 2011.

[30] Willard, H. H., Merritt, L. L. and Dean, J.A., *Instrumental method of analysis*. 3rd edition, Van No Strand, New York, 91958.

[31] Kaka, E. A., Akiti, T. T., Nartey, V. K, Bam, E. K. P. and Adomako, D., "Hydrochemistry and evaluation of groundwater suitability for irrigation and drinking purposes in the southeastern Volta river basin: manya krobo area, Ghana," *Elixir Agriculture*, vol. 39, pp. 4793-4807, 2011.

[32] Boyd, C. E., "*Water Quality: An Introduction,"* The Netherlands: Kluwer Academic Publishers Group. ISBN 07923-78539, 1999.

[33] Manivasakam, N., "Physico-chemical examination of water, sewage and industrial effluents," *Pragati Prakashan*, Meerut. India, 1980.

[34] Akashima, T., Fukunishi, N., Nishiki, T. and Konishi, Y., "Anaerobic oxidation of dissolved hydrogen sulfide in continuous culture of the chemoautotrophic bacterium Thiobacillus denitrificans," *Kagaku Kogaku Ronbunshu*, vol. 28(1), pp. 25–30, 2002.

[35] Lucassen, E. C .H. E. T., Smolders, A. J. P., Van der Salm, A. L. and Roelofs, J. G. M., "High groundwater nitrate con-centrations inhibit eutrophication of sulfate-rich freshwaterwetlands," *Biogeochemistry*, vol. 67(2), pp.249–267, 2004.

[36] Kurup, R., Persaud, R., Caesar, J. and Raja, V., "Microbiological and physiochemical analysis of drinking water in Georgetown, Guyan," *Nature and Science*, vol. 8(8), pp. 261-265, 2010.