REVIEW PAPER ON THE IMPACT OF LAND USE LAND COVER CHANGE ON WATER QUALITY.

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ABSTRACT

Anthropogenic activities/development such as mining, settlement, tourism and agriculture continues to exert pressure on the quality of surface water, most importantly in the tropical regions like Ghana. In view of this, the paper sought to review the impacts of land use land cover change resulting from anthropogenic activities on the water quality of river basins. It was established that, the location of land use activity whether close to the water body or remote do affect the quality of water so far as it is carried out within the water basin. The level and trend of water quality degradation within a water body is a factor of the intensity of land use within the basin. Land use change especially agriculture intensification and settlement/residential areas is perhaps the most salient signature of human activities on both terrestrial and aquatic environment. It is therefore recommended that there should be constant study and monitoring of the quality of water by an appropriate scientific agencies like the Water Resource Commission (WRC), Ghana Standard Authority (GSA) or an NGO like Water Aid to protect and sustain the health of the rivers and their resources in Ghana.

Keyword: - *Land Use Land Cover Change, Water Quality, River Basin.*

1. INTRODUCTION

In the 21st century, anthropogenic activities/development such as mining, settlement, tourism and agriculture continues to exert pressure on the quality of surface water, most importantly in the tropical regions like Ghana [24]. In a study on the effects of natural and anthropogenic changes on ecosystem process, Hornung and Reynolds [9] stated that, anthropogenic sources have modified the morphology of most basins and also the chemical environment. When water becomes degraded, it serves as fertile grounds for water-borne disease-carrying vectors. In the rural setting where mostly there is poor sanitation, fecal contamination of surface water could be highly prevalent [19].

In 2009, the World Health Organization reported that about 3.4 million people especially children lose their lives every year in developing countries due to water-related diseases. In Ghana, majority of people (about 50.7%) resides in the rural areas where accessibility to potable water is limited with close to 30% of the rural populace without potable water as reported by the Water Safety Management Program [23] and resort to sources like rivers, borehole and lakes for drinking and other domestic use. The quality of these water sources is uncertain, making people in the rural communities more vulnerable to water prone diseases.

Poor water quality may increase the risk of humans and aquatic life making it unfit to consume fish and other water resources from such water bodies. In most cases, untreated raw domestic waste such as human excreta, food residue and animal excreta are transported by surface runoff either when it rains or are directly discharged into the river since, to most people, the suitable way of disposing off their waste is throwing them into rivers.

According to Debary [4], a watershed is an area of land that captures water in any form and drains into a common water body. It is an axiom that before any form of flowing water drains into a receiving water body it travels through different forms of land uses, carrying with it and depositing pollutants collected as it moves over the land surface

into the recipient water body. The deposition of these pollutants into the receiving water body could compromise the quality of water within the receiving water body.

Land Use Land Cover Change (LULCC) within watershed is known to alter water balance, the process that controls water quality [25] and the vegetative cover located in and around the immediate environment of surface water bodies either directly (concentrated) or indirectly (diffused). In the same way, human settlement (urban and rural) and cultivation in close proximity to surface water bodies (river) have substantially altered the once semi-deciduous rain forest to patches of fragmented secondary vegetation and farmlands and consequently increasing the intensity of surface flow. For instance, major towns like Tarkwa-Nsueam, Prestea-Huni Valley and others near River Ankobra have seen significant improvement in mining activities, infrastructural development and conversion of large tracks of land to farmlands especially near the river banks.

One of the pervasive factors directly affecting the quality of fresh water is LULCC. Land use and management practices to a large extent, determine the quality of surface runoffs and the biodiversity of aquatic organisms in the recipient water [24]. In most parts of the world, natural vegetation or land cover is being converted from lands that serve as storage of nutrients to those that serve as sources of nutrients into the terrestrial environment especially fresh water bodies [14].

As postulated by Foley *et al*. [6], the current land use is changing the structure of ecosystem within the river basins. The health of any aquatic environment relies heavily on the interactions between the water (river), the riparian vegetation and the alterations made to the landscape around the water body. The riparian vegetation cover serves as a natural protection for water bodies, by reducing erosion, nutrient input and sedimentation through the gradual infiltration of surface run off and absorption of nutrient. Converting riparian vegetation to other forms of land use can affect water quality. The near shore areas of rivers are characterized by unique flora and fauna communities which are environmentally susceptible making them vulnerable to the slightest disturbances. This is because it is the interface between the land and the water bodies, and one of the most productive ecosystems in the world which is impacted by both aquatic and terrestrial activities [17].

These land use changes influence adjacent water bodies ranging from nutrient enrichment, alteration of hydrologic cycle, biodiversity change, and animal waste to modification of the landscape. A study by Goolsby *et al*, [8] on the role of agriculture on changes in nitrogen levels in river Mississippi concluded that, changes in nitrogen (N) levels in the river was about three times higher in less than half a decade (1996-1999) than that of the levels recorded in about more than a decade (1980-1996). In Canada, agriculture is seen as the probable cause of about 77% of degradation of rivers and streams in the Great Plains [11]. For instance, settlement (both rural and urban) within water basin is associated with nonpoint source pollution and upland-agriculture practices which affect the quality of water especially in river basins like Ankobra which is a hub of mining activities in the Western Region of Ghana. As observed by Schueler (2000), impervious layers such as roads, pavements, rooftops and others result in accelerated run-off to the receiving rivers. Similarly, a study in India attributed changes in water quality to changes in land use practices [12].

In our contemporary world, nutrient enrichment has been attributed mainly to non-point source mainly from human settlement and farmlands which has led to the degradation of many aquatic systems [2]. A survey by United States Environmental Protection Agency [20] on the major source of water quality problem reported that nonpoint source of nutrient enrichment is the major cause of 20% of rivers and 50% of lake's impairment. Similarly, Goolsby *et al.* [8] observed that, diffused source alone contributed about 90% of nitrogen to the Mississippi river. The wide-spread nature of diffused pollution makes it difficult to minimize its impact on water quality especially in a developing country like Ghana where water quality monitoring is mostly not carried out.

A report by Food and Agriculture Organization [5] indicated that, globally, the major land use change includes forest change (deforestation), change in agricultural area and management. Land use activity such as agricultural intensification has both positive and negative effects on the environment. While the use of inputs like fertilizer, manure and agro-chemicals has helped to increase crop yield, their indiscriminate use leaves residual particles on the soil which can result in deterioration of downstream aquatic ecosystem [1].

As has been observed by Reed *et. al* [13] the conversion of tropical forest within the watershed to lands for grazing and crop production result in increased ammonium ions ($NH4^+$) and dissolved organic nitrogen in the water given that there are different types of soil, nutrient availability and how each ecosystem assimilate to nutrient in the tropical region like Ghana. In Ghana like many developing countries, agricultural intensification is gradually gaining

grounds. The irony is that, most of the farmers in Ghana are not well informed. Thus, application of farm inputs like fertilizer and manure are mostly done without any prior soil testing to determine the type of nutrient supplement to apply to specific soil. Nutrients applied are mostly not required or applied in excess making such nutrients available to be eroded and deposited in a receiving water body.

Similarly, Turner and Rabalais [18] affirmed that where agricultural activity is intense, there is the production of high levels of dissolved salt, sedimentation and nutrient enrichment (phosphorus and nitrogen). Thus, there is a strong correlation between nutrient losses and land use decision. However, in recent times, there is a growing evidence that atmospheric deposition may contribute significantly to nutrient enrichment especially nitrogen [10]. Vano [21] suggested the effect of climate change on hydrology to be significant than development whereas Carpenter *et al.* [3] also argue that, the quality of water will decline in more developed areas and in areas where residential and recreational activity is dense and in turn affect the food chain of river.

2. CONCLUSIONS

In studying the correlation between LULCC and how it impact water quality, it has been established that land use activities whether far or proximate to the water do affect the water quality [22][7]. In contrast, Smith *et al.* [16] concluded that, land use activities close to water bodies are the best predictor of water quality than more distant land use. Thus, the locations of land use activity whether close to the water body or remote do affect the quality of water so far as it is carried out within the water basin. The level and trend of water quality degradation within a water body is a factor of the intensity of land use within the basin. Land use change especially agriculture intensification and settlement/residential areas is perhaps the most salient signature of human activities on both terrestrial and aquatic environment.

It is therefore recommended that NGO's, traditional rulers and other stakeholders should educate the people on the benefits of riparian management and soil conservation to protect river bodies and their watershed to reduce pollution and maintain the health of the water bodies in the basin.
There should be constant study and monitoring of the quality of water by an appropriate scientific agency like the Water Resource Commission (WRC), Ghana Standard Authority (GSA) or an NGO like Water Aid to protect and sustain the health of the river water and its resources in Ghana.
The over reliance on farming and mining activities and the use of destructive methods of farming and mining are the result of lack of alternative sources of livelihood. Government, NGO's and other private sector organizations should create alternative economic opportunities in the communities within the river basin to reduce the reliance and pressure on the lands around the river.

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4. REFERENCES

1. Beman, J. M., Francis, C. A., Roberts, K. J., Santoro, A. E., & Oakley, B. B. (2005). Ubiquity and diversity of ammonia-oxidizing archaea in water columns and sediments of the ocean. Proceedings of the National Academy of Sciences, 102(41), 14683-14688.

2. Carpenter, S. R., Cole, J. J., Essington, T. E., Hodgson, J. R., Houser, J. N., Kitchell, J. F., & Pace, M. L. (1998). Evaluating alternative explanations in ecosystem experiments. Ecosystems, 1(4), 335-344.

3. Carpenter, S. R., Stanley, E. H., & Vander Zanden, M. J. (2011). State of the world's freshwater ecosystems: physical, chemical, and biological changes. Annual review of Environment and Resources, 36, 75-99.

4. Debary P., (2002). "Watersheds; Processes, Assessment and Management" John Wiley and Sons. Inc. 700 pp.

5. F.A.O (2003). Pan-tropical survey of forest cover changes 1980-2000. FRA Working Papers 56

6. Foley, J. A., DeFries, R., Asner, G. P., Barford, C., Bonan, G., Carpenter, S. R., ... & Helkowski, J. H. (2005). Global consequences of land use. science, 309(5734), 570-574.

7. Ghana Raw Water Quality Criteria and Guidelines, Volume 1, Domestic Water-Use," Water Resources Commission, Accra, 2003

8. Goolsby D.A., Battaglin W.A., Lawrence G.B. & Keeney D.R., (1999). "Flow and Sources of Nutrient in the Mississippi Atchafalaya River Basin: third Report for the Integrated Assessment of Hypoxia in Gulf of Mexico" NOAA Costal Ocean Program Decision

9. Hornung, M., & Reynolds, B. (1995). The effects of natural and anthropogenic environmental changes on ecosystem processes at the catchment scale. Trends in ecology & evolution, 10(11), 443-449.

10. Jaworski, N. A., Howarth, R. W., & Hetling, L. J. (1997). Atmospheric deposition of nitrogen oxides onto the landscape contributes to coastal eutrophication in the northeast United States. Environmental Science & Technology, 31(7), 1995-2004.

11. Narini, M. (2016). An investigation of land-use impacts on water quality and algal communities in the Nottawasaga River and low-order streams of the Nottawasaga Valley Watershed (Doctoral dissertation, University of Ontario Institute of Technology (Canada)).

12. Raj, N., & Azeez, P. A. (2009). Spatial and temporal variation in surface water chemistry of a tropical river, the river Bharathapuzha, India. Current Science, 245-251.

13. Reed S.C., Cleveland C.C., & Townsend A.R (2008). Tree species control rates of free-living nitrogen fixation in a tropical rain forest. Ecology 89:2924-2934

14. Rosegrant, M.W., Meijer S., & Cline S., (2000). "International Models for Policy analysis of Agricultural Commodities and Trade (IMPACT)" Model Description. Tech. Report. International Food Policy Research Institute, Washington, DC. (www.ifpri.org/ accessed, 2005, May)

15. Schueler, T. R., & Holland, H. K. (2000). Practice of watershed protection.

16. Smith, A. J., Bode, R. W., Tran, C. P., & Kleppel, G. S. (2010). Land-use proximity as a basis for assessing stream water quality in New York State (USA). Ecological Indicators, 10(3), 727-733.

17. Thorp, L. (1997). Access to land: a rural perspective on tradition and resources.

18. Turner R.E., & Rabalais N.K. (2003). "Linking Landscape and Water Quality in the Mississippi River Basin for 200 Years" Bioscience 53(6) 563-572.

19. Twongo, T., & Rother, J. A. (1999). Water hyacinth in the Shire River: techniques for monitoring biodiversity impacts and a baseline survey. Unpublished report to DFID/Government of Malawi/CABI for Lower Shire water hyacinth biological control project.

20. United States Environmental Protection Agency (USEPA) (2006)

21. Vano, J. A., Cardille, J. A., Carpenter, S. R., Foley, J. A., Hanson, P. C., & Turner, M. G., (2009). Climate change and lakes: Estimating sensitivities of water and carbon budgets. Journal of Geophysical Research: Biogeosciences, 114(G3).

22. Water Resources Management Study—Information Building Blocks Study," Final Report, Ministry of Works and Housing, Accra, 1998.

23. Water Safety Management Program (2009)

24. Wireko, A. (2015). Impacts of Land Use/Cover Change on Water Quality in Lake Bosomtwi Basin of Ghana (Doctoral dissertation, University of Ghana).

25. Zampella, R. A., Procopio, N. A., Lathrop, R. G., & Dow, C. L. (2007). Relationship of Land-Use/Land-Cover Patterns and Surface-Water Quality in The Mullica River Basin 1. JAWRA Journal of the American Water Resources Association, 43(3), 594-604.

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