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Qualitative Assessment of Effects of Encroachment on Water Resources of Agba Dam, Ilorin Nigeria

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Abstract
The city of Ilorin in Nigeria has experienced high population growth and rapid urbanization. Agba Dam is one of the major sources of potable water in Ilorin, and currently been threatened by anthropogenic induced encroachment activities, with potential for significant derogatory effects on its quality. Therefore, this paper assesses the qualitative impact of encroachment on the water resources regime of Agba Dam, Ilorin, Nigeria. Field survey was carried out to scope proximal anthropogenic activities and to delineate historical and current extent of the encroachment area of the dam. Representative water samples were collected from locations within the dam catchment, and subsequently analyzed for alkalinity, dissolved carbondioxide, chloride, total iron, copper, sulphate, colour, calcium, dissolved oxygen and turbidity. In addition, historical physical and chemical data of water samples obtained from the dam were also acquired, and analyzed to determine temporal variation in the quality. The results show a reduction of 0.89 km^2 or 63% in the historical buffer boundary of the dam. The values of the measured physico-chemical parameters were generally similar to that obtained for the historical values and therefore suggest limited impact of the anthropogenic activities on the water quality. However, slight increases were observed in the measured concentrations of the alkalinity, dissolved carbondioxide, chloride, iron, copper and sulphate, and this indicates possibilities of water quality alteration, with potential consequences for ecosystem and aquatic life if the trend is unabated.
Keywords: Anthropogenic, Water quality, Agba dam, Ilorin Nigeria

1.0 Introduction

The importance of water to life cannot be over-emphasized and several authors have established that human survival is more dependent on water relative to food (Wahlquist, 2009; EFSA, 2010). Also, approximately 1.3 billion people of the global population have no access to safe and adequate water supply and more than 85% of these people live in developing countries. In 2025, it is projected that approximately 48 countries of the world are expected to face shortages of water, affecting more than 2.8 billion people who constitutes approximately 35% of the world population (UNFPA, 1997; VWG, 2008).

The perennial problem of water scarcity affects many developing nations (Vairavamoorthy *et al.,* 2008), and this has resulted in spread of diseases, conflicts among nations for control, increase in mortality rate and pressure on the environment. In Nigeria, provision of potable water is a critical factor in achieving the Nigerian Government's goal of "Health for all" in year 2020. Although, successive governments make the provision of potable water their key goal, however this seems never totally achieved partly due to the effect of increase in the population which consequently led to increased demand in the water requirements. Hence, obtaining sufficient water of adequate quality has become a challenge. The global future experience of water scarcity does not necessarily imply lack of the resource, but rather a reminder that with the continuing pollution and consequent deterioration of water quality on a global basis, the argument will shift from water availability to water safety. Water pollution therefore constitutes one of the major factors that are expected to cause future global water scarcity. Water pollution affects plants and organism living in water and the natural biological communities including human beings as well as the biodiversity of the water resources (Onunkwo, 2012).

The city of Ilorin in the southwestern part of Nigeria became the capital of Kwara State in July 1967, and has since experienced over 200% increase in population (NPC, 2010). One of the major water dam reservoirs in Ilorin is Agba Dam, commissioned in 1952. The enactment of the Landuse Acts of 1972 led to increased urbanisation, civilisation, and industrialization, which subsequently caused significant encroachment on the catchment of Agba Dam.

Mishra and Griffin, (2010) examined the impact of encroachment and anthropogenic alteration of hydrology on resource sustainability of Chilika Lake in China. The authors observed that the alteration caused severe loss to the native biodiversity and significant decline in the lagoons natural resources and quality of life around the lagoon. Hence, it was concluded that the economic health of a region depends largely upon the sustainable utilization of its natural resources including water (Walker, 2001; Mishra and Griffin, 2010; Astaraie-Imani, *et. al.,* 2012). Any significant threat to the natural resources can consequently cause corresponding effects on the livelihoods of the local population. Also, Kakekodi and Nayampalli (2003) concluded that anthropogenic activities can exert pressure on the prevailing equilibrium between ecology and local communities. Chavula (1993) noted that the issue of water shortage in Malawi is as a result of poor management of the catchment areas of its water resources, namely unfriendly agricultural practices, rapid population growth and inappropriate discharge of industrial wastes. These consequently caused soil erosion, sedimentation problems and the prevalence of turbid waters. The encroachment of Mesquite trees in upper San Pedro watershed has caused increase of 9.8 % in the annual evapotranspiration of the basin and a corresponding decrease in the annual water yield and percolation (Ceballos *et. al.*, 2010; Jackson *et al.*, 2002). The issue of erosion and flood is also considered as one of the effects of encroachment within the River Ogunpa Catchment in Ibadan, Nigeria. According to Damilola (2012), the case of River Ogunpa is caused by anthropogenic activities which greatly influenced runoff through unregulated landuse, lack of proper town planning, and indiscriminate refuse dumping. The cumulative effects may eventually lead to water scarcity. Therefore, the aim of this paper is to assess the qualitative impact of encroachment on the water quality regime of Agba Dam, Ilorin, Nigeria.

2.0. Description of the study area

The study area is located in Ilorin, Kwara State (Figure 1), and centred at approximately by $4^{0}35'$ E and $8^{0}28'$ N. Ilorin metropolis is topographically an undulating plain land with gentle slope surfaces towards the rivers and streams channels. Climatically, the town enjoy both wet and dry season. Relative humidity remains high throughout the year. The annual rainfall is between 1,250 and 1,800 mm. The wet season usually starts in March/April to October/November, while the dry season spans between November / December to March. Average temperature in Ilorin varies between 33^{o}C in February to April and 22^{o}C in July – August. Ilorin metropolis has three surface water dams namely, Agba, Asa and Sobi, commissioned in the years 1952, 1976 and 1981, respectively. Agba Dam is an earth Dam covering approximately 326,000 m^{2} and has two springs as its source. The dam serves approximately one third of Ilorin metropolis.

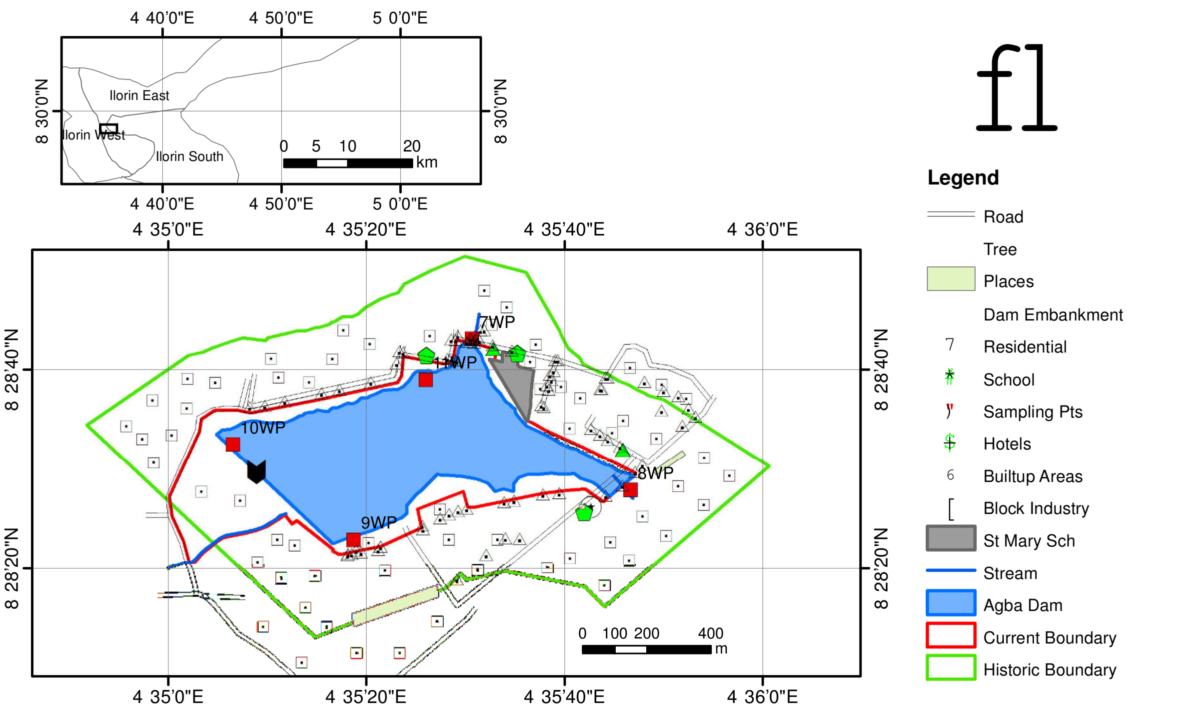


Figure 1: Boundaries and anthropogenic activities within the study area

3.0 Methodology

Field survey using Garmin 76 CSX was carried out to delineate the current extent of the buffer zone around the dam's catchment. The buffer zone is defined as the distances between the built up areas and the dam reservoir. The expected 250 m buffer stipulated by the Land and Survey Department of Kwara State Government was also surveyed and delineated. In addition, the anthropogenic activities within the catchment of the reservoir was also surveyed and scoped. The boundaries of the actual and expected buffer zones, as well as locations of the scoped proximal anthropogenic activities were plotted on the basemap using GIS utilities.

Representative water samples were collected from locations within the catchment of the dam, using thoroughly rinsed 500 ml sampling bottle, and properly stored for subsequent delivery to the laboratory. The water samples were analyzed for the following water impact indicator parameters namely alkalinity, dissolved carbondioxide, chloride, total iron, copper, sulphate, colour, calcium, dissolved oxygen and turbidity. The true color was determined by removing all suspended substances through filtration and the colour measured by visual comparison with a series of specific colour scale using spectrophotometer. The turbidity was measured using Nephelometer. The total alkalinity (as $CaCO_3$ in mg/L) was determined using H_2SO_4 standard titration method. The chloride concentration was measured using silver nitrate solution titration method, while total iron concentration was determined using spectrophotometer. Sulphate was calculated by turbidometric method, while dissolved oxygen was calculated using membrane electrode method. In addition, available historical physical and chemical analytical data were acquired from the Kwara State Water Board, Ilorin. The trends of the physico-chemical data were evaluated to determine temporal variation in the data, and measures were proffered to mitigating any observation of the effects on the encroachment of water resources of Agba Dam.

4.0 Results and discussion

The results of the survey of the historic and the current boundaries, as well as the anthropogenic activities are presented in Figure 1. The perimeters of the historic and current boundaries of the buffers of Agba Dam were approximately 5.2 km and 3.8 km, while the corresponding areas were 1.41 km^2 and 0.52 km^2, respectively. This indicated a reduction of 0.89 km^2 or 63% of the historical buffer of the dam boundary. The extent of this reduction is considered significant and largely due to increase in the anthropogenic activities, and with implications for the quality of the Agba Dam water and the associated ecosystems.

The distribution of anthropogenic activities within the proximal distance of the dam is presented in Figure 2, and includes residential (91%), hotels (4%), recreation centre, schools (2%), dumpsites (2%), and block making industries (1%), as well as agricultural activities including tree cuttings. These anthropogenic activities are associated with waste disposal facilities, discharges of effluents, waste waters from swimming pools and soakaways. The results of the physical and chemical parameters of both historic and current water samples are presented in Figures 3 - 4. The values of the physico-chemical parameters are generally similar to that obtained for the historical values and therefore suggest that the proximal anthropogenic and encroachment activities have limited effects on the quality of the water in the dam, perhaps due to the large surface area of the dam of approximately 326,000m^2.

The concentrations of the following measured chemical parameters namely alkalinity, dissolved carbondioxide, chloride, total iron, copper and sulphate showed increase compared with the corresponding historical values. Alkalinity indicates the presence bicarbonates and hydroxides, and it reflects the degree of buffer capacity of the solution. Hence, the observed 18 % increase in the measured value compared to the historical value explains the observed decrease of 15 % in the corresponding pH values, which indicated acidity. The observed increase in the dissolved carbondioxide concentration may partly be caused by the respiratory activities of algae concentration. Increased carbondioxide concentration suggests reduction in dissolved oxygen, and this has consequence for the ecosystem and aquatic life. In addition, the cutting of trees can potentially depict the amount of oxygen supplied for the Bichemical Oxygen Demand, as well as causing increase in the temperature of the water resources. The observed increase in the average chloride concentration from historical value of 3.5 mg/l to measured value of 25mg/l, suggests sewage pollution perhaps due to direct discharge of sewage effluent into the water body. The increased total iron and copper concentrations are likely caused by drainage and industrial discharges of waste effluent from the anthropogenic activities, which potentially can be significantly toxic and affect aquatic life. The increase in the sulphate concentration is probably due to sewage effluent as well as surface run-off from agricultural and cement wastes. This may however indicate possible presence of pathogenic micro-organisms.

The measured parameter values that were lower than corresponding historical values include colour, calcium, dissolved oxygen and turbidity (Figure 4). The colour parameter is an indicator of the presence of complex organic molecules derived from vegetable matter such as peat and leaves. The observed reduction in the measured values is likely due to reduction in the farming activities which historically dominated the catchment area, and now replaced with fenced structures. Calcium is a naturally occurring elements and its concentration often play significant roles in determining the difference between natural potable water and polluted water. Hence, its depletion suggests catchment alteration by anthropogenic activities. In addition, organic and inorganic pollution are also responsible for the reduction of water natural constituents. Depletion of dissolved oxygen indicates the presence of bacteria which have utilized the dissolved oxygen during the process of degradation of waste. This suggests that rate of bacterial uptake of oxygen is greater than the rate at which the dissolved oxygen is replenished from the atmosphere. This consequently indicates occurrence of pollution with significant content of microorganisms probably from the anthropogenic activities. Generally, turbidity is caused by the presence of both organic and biological sludge, as well as washings of silt, sand, clay particles and sewage solids. Hence, its reduction is thought to be due increase in the area that constituted hard surfaces resulting from the anthropogenic activities, which subsequently reduces the inflow of soil and clay particles into the dam.

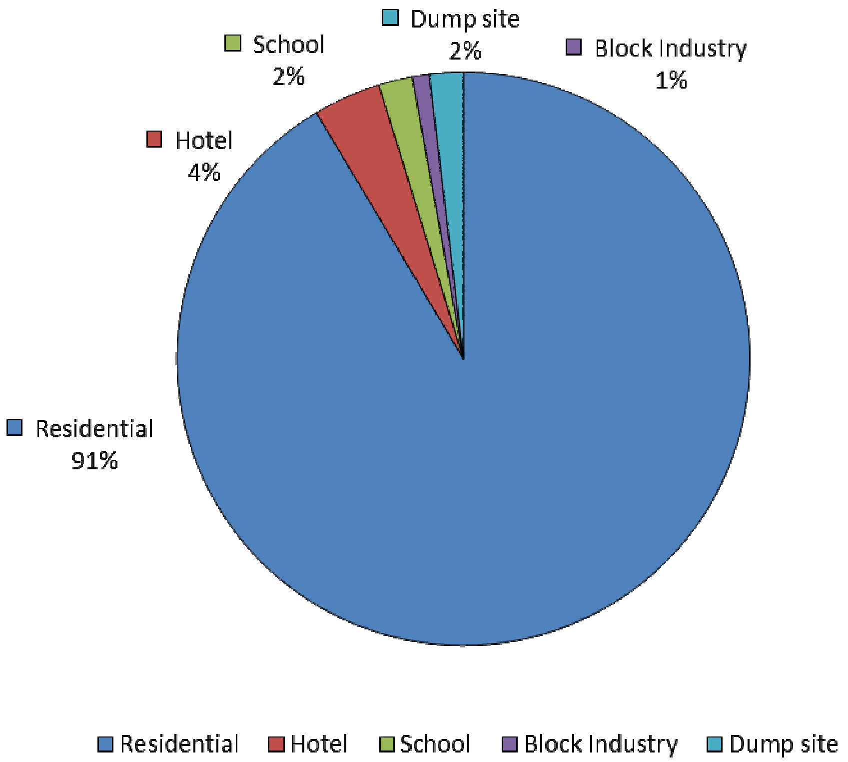
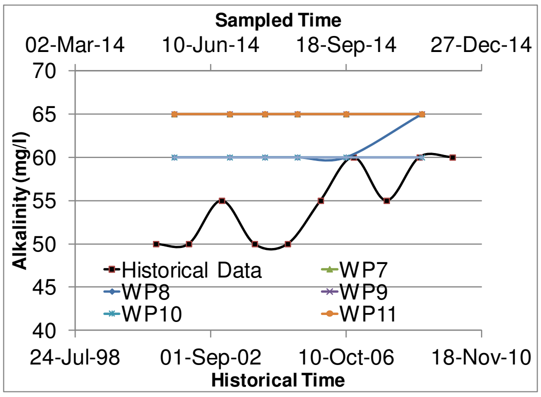


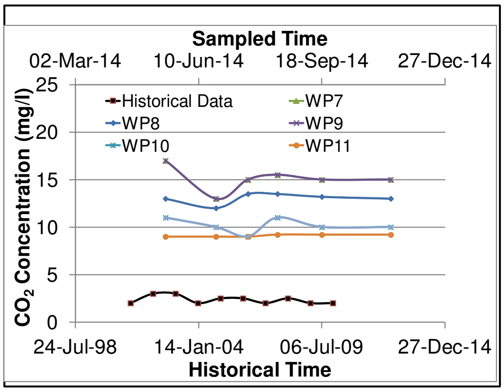
Figure 2: Distribution of proximal anthropogenic activities

5.0 Conclusions

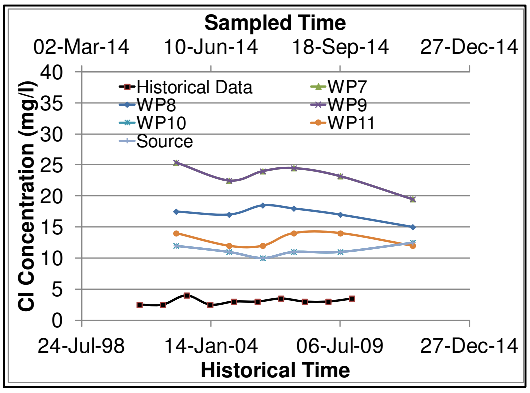
A significant reduction of 63 % of the historical buffer boundary of the dam was observed which suggests potential impact on the catchment and consequently on the quality of the Agba Dam water resources with implications for the ecosystem. Scoped anthropogenic activities within the proximal distance of the dam include residential, hotels, schools, block industry, dump site areas with associated discharges of effluents. Considering the extent of area covered by the dam and the distribution of anthropogenic activities, it was concluded that the activities have limited effects in the short term, which may become significant on the long term, with potential consequence for the quality of water in the dam. In addition, the values of the physico-chemical parameters are generally similar to that obtained for the historical values and therefore collaborated earlier deduction that the proximal anthropogenic and encroachment activities have limited effect on the quality of the water in the dam. The trends of Bichemical Oxygen Demand, dissolved carbondioxide, dissolved oxygen and sulphate concentrations in the results of the water analyses indicate possibilities of sewage pollution and consequently possible presence of pathogenic micro-organisms, with potential consequences for ecosystem and aquatic life. Enforcement of compliance of relevant environmental laws that will ensure that effluent discharges are limited to acceptable regulatory values as well as prevention of further encroachment of the remaining catchment area are required in order to mitigate against further derogatory effects of the encroachment of water resources of Agba Dam.



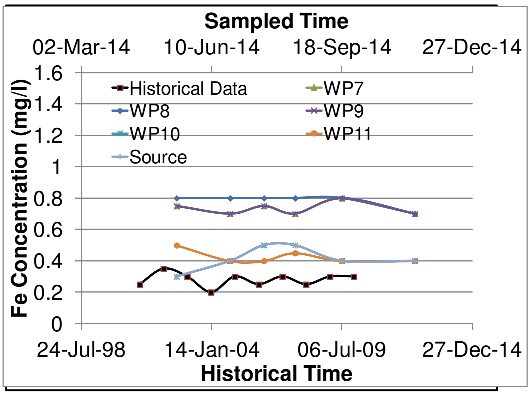
(a) Alkalinity



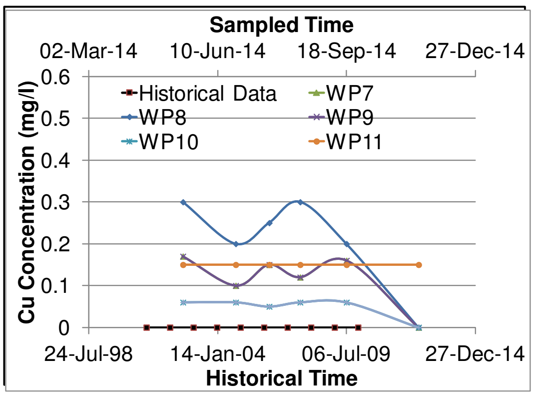
(b) Carbondioxide



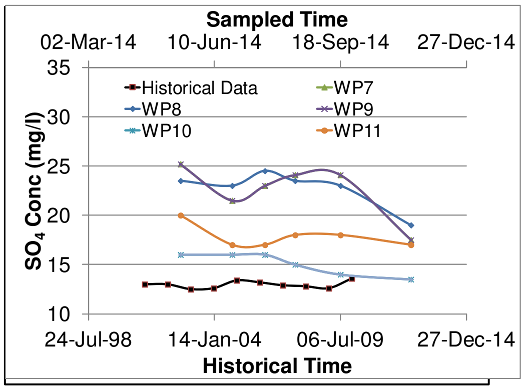
(c) Chloride



(d) Iron

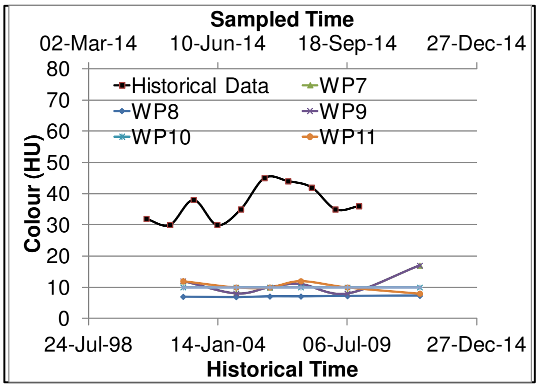


(e) Copper

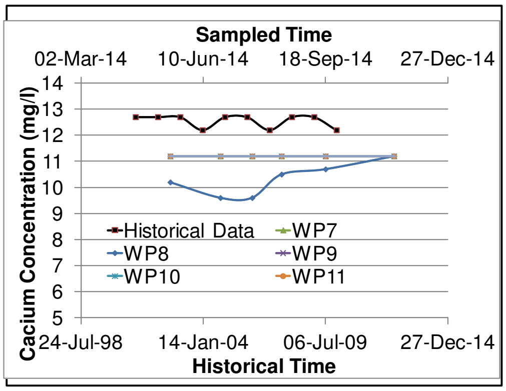


(f) Sulphate

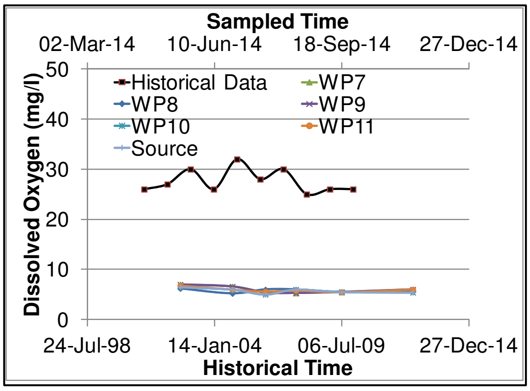
Figure 3: Measured parameters with increased concentrations



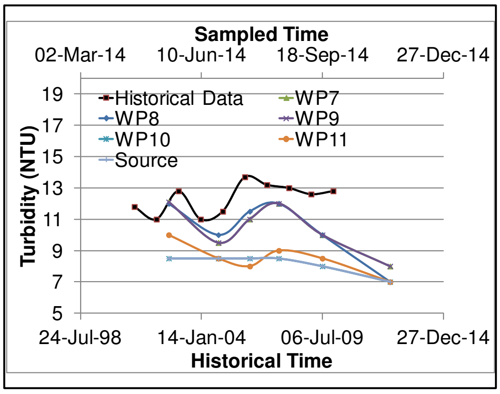
(a) Colour



(b) Calcium



(c) Dissolved Oxygen



(d) Turbidity

Figure 4: Measured parameters with decreased concentrations

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