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ASSESSMENT OF WATER QUALITY USING BIOLOGICAL MONITORING WORKING PARTY (BMWP) AND AVERAGE SCORE PER TAXON (ASPT) SCORE AT KANYE AND MAGAGA DAMS, KANO

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ABSTRACT
Macro invertebrate biotic indices have been widely used to assess quality of water bodies in the world. The Biological Monitoring Working Party (BMWP) and its Average Score Per Taxon (ASPT) score system is one of the most common biotic indices in use and has been applied to various streams and rivers throughout Europe and world. This study examines the water quality at Kanye and Magaga Dams using the BMWP/ASPT score index for the first time. Macro invertebrates were sampled from the upper and lower parts of the Dam using standard kick sampling techniques and identified to family level. The computed BMWP/ASPT score revealed higher value at the upper parts than the lower parts of the Dams. Kanye Dam showed a cumulative BMWP/ASPT scores of 50 and 3.85 while at Madaga Dam the cumulative BMWP/ASPT scores were 61 and 2.66 respectively, which are within class III category of moderately polluted water body. One way analysis of variance result revealed a significant difference (p<0.05) in BMWP/ASPT score value between the lower and upper part of both Dams. The result showed macro invertebrates were more diverse at the upper part than the lower part of the Dams. This study has further strengthened the use of BMWP/ASPT score index as an index of organic pollution in Nigerian water bodies. However additional application and validation is required to develop an adopted version BMWP/ASPT score index based on the sensitivity of our local taxa.
Key words: Biotic index, Macro invertebrates, Pollution,

INTRODUCTION

Biological assessments of running waters have long been incorporated within physical, chemical assessments to provide complete information for an effective water management (Metcalfe, 1989). This is because biological assessment methods have more advantage over the chemical assessments. For instance organisms tend to combine environmental conditions over long periods of time, while chemical data represent the present condition of water body and depends upon numerous measurements for accurate result (Mason, 2002). Biotic indices are numerical expressions combining a quantitative measure of species diversity and qualitative information on ecological sensitivity of individual taxa (Czerniawska-kusza, 2005). More so, biotic indices take account of the sensitivity or tolerance of individual species or groups to pollution and assign them a value and the sum of which gives an index of pollution for a site (Mason, 2002). Biotic indices are generally specific to a type of pollution, usually designed to assess organic pollution (Stark, 1998). However many biotic indices are regional specific, because different taxa are found in different geographical areas. As such a biotic index developed in one country cannot be applied without modification in another (Kalyoncu and Zeybeck, 2011). This has led to the development of numerous biotic indices to monitor water quality in different countries (Metcalfe-smith, 1996). Several Biotic indices have been developed and applied in water quality assessments these include the British Biological Monitoring Working Party system (BMWP), with its Average score per Taxon (ASPT) variant (Armitage *et al.,* 1983). The BMWP score was designed to give a broad indication of the biological condition of rivers throughout the United Kingdom (Mason, 2002); the South African Score system(SASS) for South African streams and rivers is arrived at by assignment of quality values to the various taxa on empirical basis between 0 and 10(Chutter,1972);Belgian Biotic index(BBI)(De Pauw and Vanhooren, 1983) has been applied for routine water monitoring by the Flemish Environment Agency; the Spanish Biological monitoring water Quality(BMWQ)Score system applied in Spain(Camargo,1993).

The Biological Monitoring Working Party (BMWP) score system is one of the most common biotic indices in use and has been applied to various streams and rivers throughout Europe and world (Roche *et al.,* 2010). This index allocates a single score to benthic macro invertebrates at the family level that is representative of the family's tolerance to water pollution, the greater their tolerance to pollution, the lower the BMWP score and vice versa (Armitage *et al.,* 1983). The BMWP system has been applied to various streams throughout Europe, but evaluations of its performance are few. Studies by Armitage *et al.,* (1983) evaluated the performance of the BMWP score and ASPT at 268 sites on 41 rivers in Great Britain over a wide range of unpolluted running water. The result showed that, ASPT is less influenced by season than the BMWP, indicating that samples collecting in any season will give consistent values of ASPT. ASPT was also shown to be more independent of sample size than the BMWP score, implying that more information can be obtained with less effort.

Camargo and Gonzalo, (2007) in their study in the Tajuna River in Spain using the several adoptions of BMWP score and their average scores ASPT. Found that the correlations between the indices with chemical parameters are higher with average scores (ASPT, ASPT′) than with total scores (BMWP, BMWP′). Similar studies by Pinder *et al.,* (1987) in their study on the chalk streams in England compared the performances of four diversity indices and three biotic indices or score including the (BMWP), and ASPT. They found BMWP/ASPT to be superior then other indices because it was little affected by sample size and were found to be simple to calculate and required a limited degree of taxonomic expertise. More recently studies by Vernofaderamy *et al.,* (2010) in the Zayandeh River basin in Iran, found that the BMWP, ASPT and the revised BMWP, ASPT have positive correlation with percentage oxygen saturation, water flow and PH. The indices have showed greater correlation with water quality parameters than that of the richness and diversity indices.

The adoption of biotic indices in differently region requires prior modification according to environmental conditions or pollution types (Mustow, 2002). The BMWP score system developed for pollution surveys in the UK (Armitage *et al.,* 1983), have been successfully adopted and applied in Countries through the addition of local taxa and removal of absent taxa (Mustow, 2002). Many studies have showed the applicability of BMWP index and its modified versions in the different countries. For example in Poland research by (Czerniawska-Kusza, 2005), has showed the adaption of modified version of BMWP called BMWP (PL) index , and was successful in differentiating polluted sites from relatively un polluted sites. Similarly an adopted version of BMWP index in Brazil by (Cot *et al.,* 2003) and in Thailand called (BMWP THAI) by (Mustow, 2002) were both applied for monitoring changes in water quality. Others modifications and adoptions of BMWP were in Spain (Zamora-Munoz *et al.* 1995), Italy (Solimini *et al.,* 2000), Greece (Artemiadou and Lazaridou, 2005), Portugal (Faria *et al.,* 2006), Brazil (Silveira *et al.,* 2005), Malaysia (Azrina *et al.,* 2006), Egypt (Fishar and Williams, 2008), and Iran (Vernosfaderany *et al.,* 2010). However in Nigeria to date only few studies have tested the suitability and practicability of BMWP/ASPT score index as an index of organic pollution in Nigerian water bodies. Hence this study seeks to evaluate the water quality at Kanye and Magaga Dams using the BMWP/ASPT score index.

MATERIALS AND METHODS

Study area

The study was carried out at Kanye and Magaga Dams situated on latitude 11^{o} 97′N, longitude 8^{o} 1′E and latitude 11^{o} 97N, longitude 8^{o}1E for respectively. Both Dams are located along Gwarzo road in Kabo Local Government Area Kano State in Sudan Savannah zone of Nigeria with two distinct reasons (dry and wet). The rainy season lasts from May to October while the dry season lasts from November to April yearly. Kanye Dam was impounded and commissioned in 1970 during the regime of the former governor of Kano state Audu Bako (Abdullahi *et al*., 2017). While Magaga Dam has a reservoir capacity of 17.22 million $m^3$and 119squarekilometers surface area of the water and was impounded and commissioned since 1988 (Abdullahi *et al*., 2017).

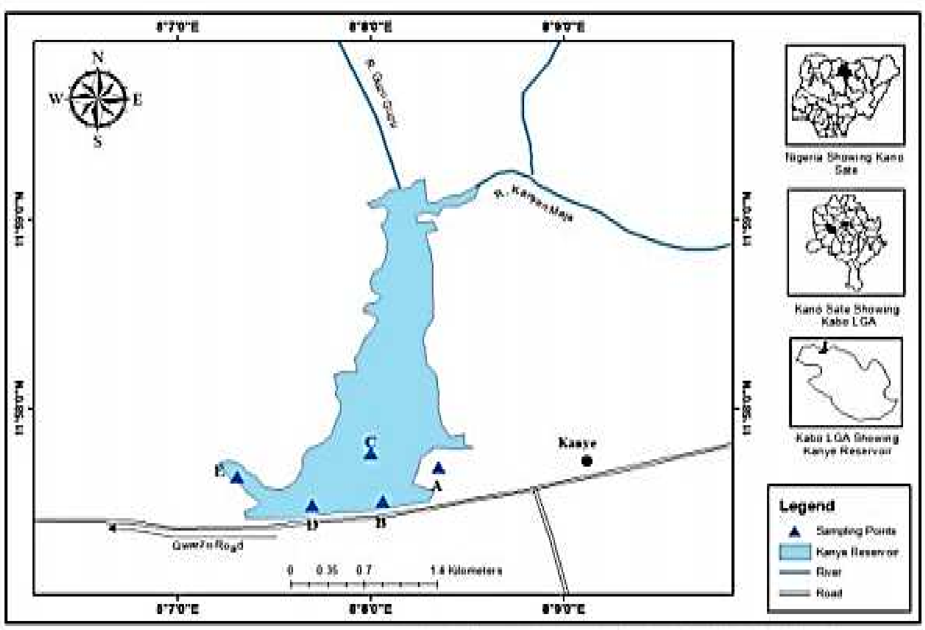

Figure 3.1: Map of Kanye Dam showing the sampling sites (Source: Cartography Lab. Department of Geography BUK, 2014).

Sampling design

A total of 40 sites were sampled based on intensity/type of anthropogenic activities and at each sampling site three replicates of samples were collected. Each Dam was divided into 20 sampling sites, 10 sampling sites in the upper parts and 10 sampling sites in the lower parts in accordance with (Mason, 2002).

Collection of macro invertebrates

Kanye and Magaga Dams were studied between the month of August and October, 2017 during wet season. Three replicates of samples were collected randomly from the selected sites. Three minute kick sampling were taken at each site using the standard 1mm mesh size net and sweeping net. The substratum upstream of the net was vigorously disturbed to dislodged invertebrates flow into the net in accordance with (Mason, 2002). Samples were empty into a white try and macro invertebrates were sorted and identified to family level, counted and recorded in the field. However other macro invertebrates were preserved with alcohol and transported back to Bayero University, Kano laboratory for identification as suggested by (Bartram and Balance, 1996). Macro invertebrates were further sorted on a petri dish in the laboratory and identified into family level using microscope and identifications keys. The following identification keys were used to identify macro invertebrates to family level (Quigley, 1977; Croft, 1986; Dobson *et al.,* 2012; and Wallace, 2006).

Sample analysis

Samples were analyzed by allocating a score between 1 and 10 to each group or family according to their sensitivity or tolerance of the macro invertebrates to the pollution in an aquatic ecosystem. The score is called Biological Working Party (BMWP) score. The Higher the (BMWP) score the clearer the water. The average score per taxa (ASPT) is obtained by dividing the BMWP score by the total number of families in the sample. In accordance to (Bartram and Balance, 1996) each group or family of macro invertebrates sampled at each site were allocated the BMWP score according to their sensitivity to environmental disturbance. Each scores for each family represented in the sample for sites, were summed to generate the BMWP score.

Average score per taxa (ASPT) value for each site were obtained and recorded following Bartram and Balance (1996) evaluation technique below.

$$\text{ASPT} = \frac{summation of BMWP score}{Total number of species sampled}$$

Statistical analysis

The data obtained from biological monitoring working party (BMWP) and average score per taxa (ASPT) score were analyzed using R statistical software version 2014. One way analysis of variance (ANOVA) was used to determine whether there is a significant difference in Biological Monitoring Working Party (BMWP) score and Average score per taxa (ASPT) between the upper part and lower part of the Dams as described by (Dytham, 2011).

RESULTS

One way analysis of variance result revealed a significant difference ($p<0.05$) in BMWP score between the upper and lower parts of the Dams (Table 1). The ASPT score also showed a significant different between the upper parts and lower parts of the Dams (Table 1) (Figure 4, 5). The cumulative BMWP score revealed a BMWP score of 61 and 50 score for Magaga and Kanye Dam respectively (Table 2 and 3), both BMWP scores are within class II category of slightly polluted water (Table 2, 3) (Appendix 2). The result revealed ASPT score of 2.66 and 3.85 for Magaga and Kanye Dam respectively (Appendix 2, 3) and the ASPT scores are within class II category of slightly polluted water.

Table 1. Analysis of variance Anova result of BMWP/ASPT between the lower and upper part

Site	Variables	Mean square	d.f	F. value	P. value
Kanye Dam	BMWP	1394.450	1	49.206	**0.00**
	ASPT	74.498	1	42.741	**0.00**
Magaga Dam	BMWP	296.450	1	15.635	**0.001**
	ASPT	22.898	1	33.884	**0.00**

Note: P. value are significant at <0.05 are bold and underline

The result revealed a total of seven macro invertebrates' species at Magaga Dam with 15 families. Aquatic beetle had the highest number of frequency of occurrence with 155, followed by Snail with 95 and Oligochaeta worm with 88 (Table 2, Figure 2). Sow bug had 53, Caddis fly 50, while May fly had 14 and Cray fish had the least with 8 (Figure 2). The result showed a significance difference in frequency between Aquatic beetle, Cray fish and all the other macro invertebrates (Figure 2). At Kanye Dam the result revealed a total of six macro invertebrate with 13 families. Oligochaeta worms had the highest with 149 individuals, followed by the snails with 89 individuals (Table 2, Figure 2). Aquatic bugs with 52, followed by the caddis fly with 44. The Aquatic beetle has 28, while mayfly had the least with 13 (Table 2, Figure 2). The result showed significant difference in the frequency of occurrence between Ologochaeta, Snail and all other macro invertebrate species (Figure 2).

Table 2. Macro invertebrate's species identified to family level at Magaga Dam and their BMWP score

Species	Family	BMWP Score
Caddis fly	*Psychomyiidae*	8
Cray fish	*Cambaridae*	8
May fly	*Baetidae*	4
Aquatic bug	*Corixidae*	5
Aquatic beetle	*Hydrobidae*	5
	Elminthidae	5
Oligochaeta	*Tubificidae*	1
	Lumbiculidae	1
Snail	*Tharidae*	3
	Ancylidae	3
	Lymnaeidae	3
	Physidae	3
	Planorbidae	3
	Hydrobidae	3
	Vivparidae	6
	Total Score	61

Table 3. Macro invertebrate's species identified to family at Kanye Dam and their BMWP score

Species	Family	BMWP score
Caddis fly	*Psychomyiidae*	8
Mayfly	*Baetidae*	4
Aquatic bug	*Corixidae*	5
Aquatic beetle	*Hydrobidae*	5
	Elminthidae	5
Oligochaeta	*Tubificidae*	1
	Lymbiculidae	1
Snail	*Tharidae*	3
	Lymnaeidae	3
	Physidae	3
	Planorbidae	3
	Hydrobidae	3
	Vivparidae	6
	Total score	50

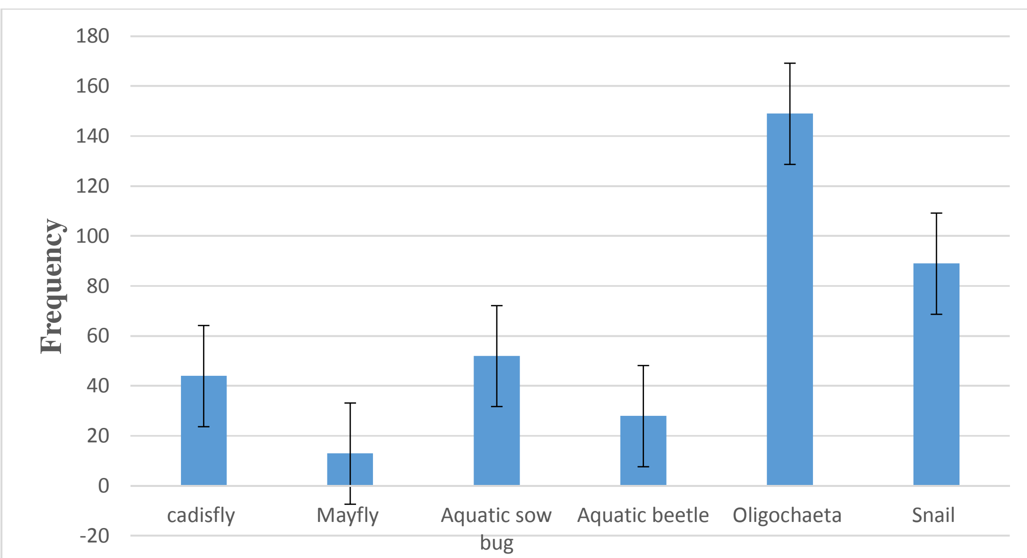

Figure 1. Comparison of frequency distribution of species sampled at Kanye Dam

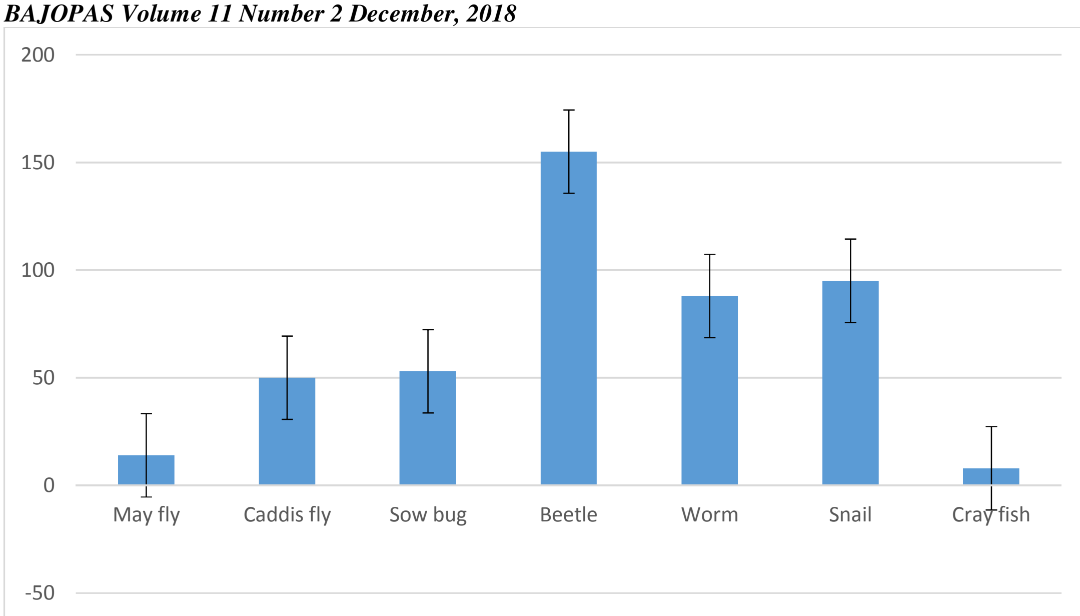

Figure 2. Comparison of frequency distribution of species sampled at Magaga Dam

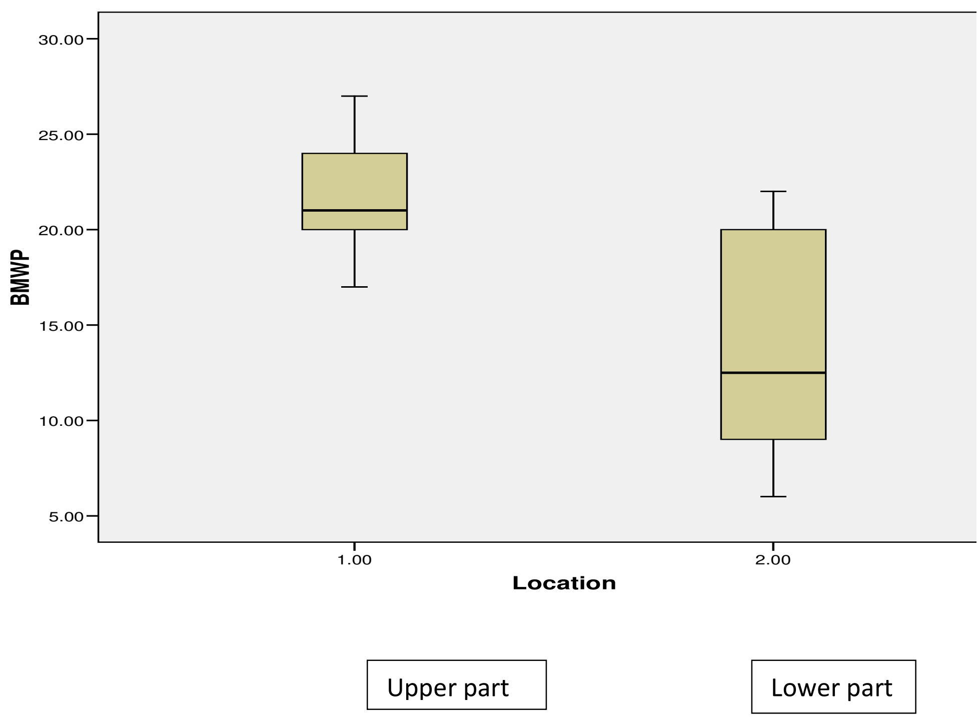

Figure 3. Comparison of BMWP score between the upper parts and lower parts at Kanye Dam

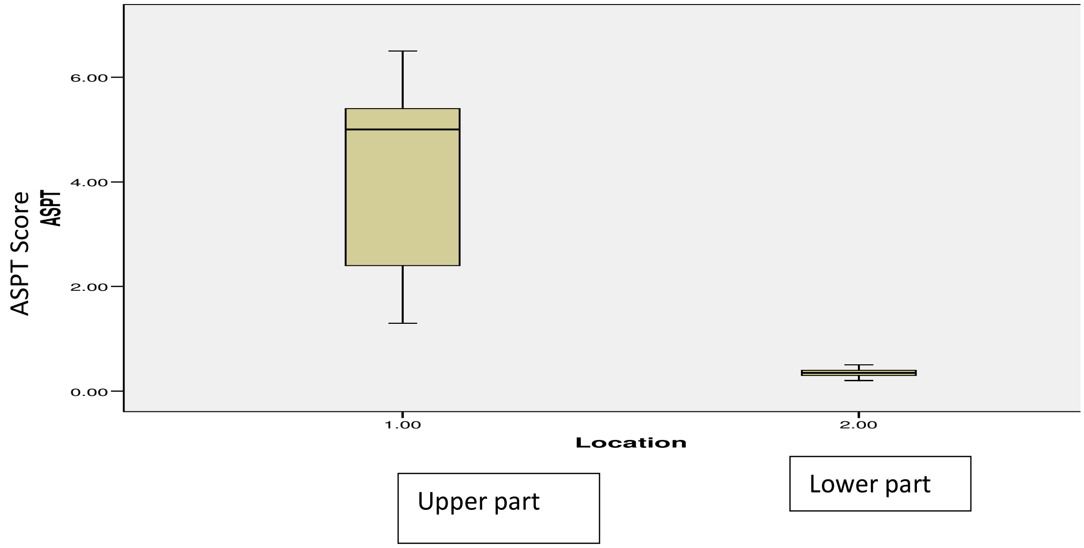

Figure 4. Comparison of ASPT between the upper part and lower part at Magaga Dam

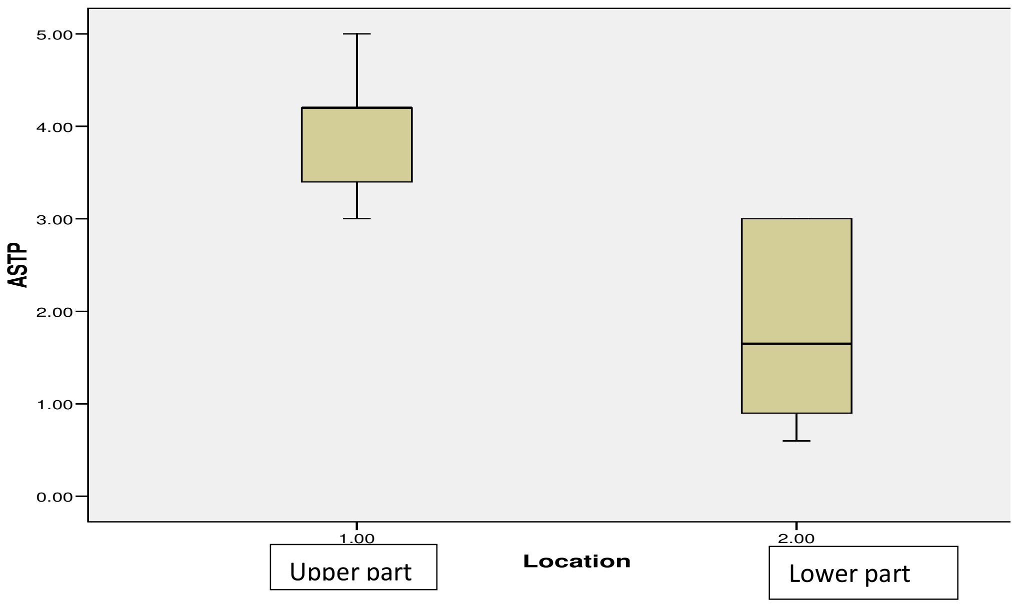

Figure 5. Comparison of ASPT between the upper part and lower part of Kanye Dam

DISCUSSION

This study showed a significant difference ($p<0.05$) in BMWP score between the upper and lower parts of Kanye and Magaga Dams. The study also found a significant difference in ASPT score between the upper parts and lower parts of the Dams. This findings indicated that the BMWP score and ASPT score are higher in the upper parts than the lower parts of the Dams. The decreased in BMWP and ASPT scores from the upper and lower parts of the dam may be due to the effects of lower flow rate. The upper parts is characterized with higher flow and fast flowing water than the lower parts of the Dams. Studies by Giller and Malmqvist, (1998) have showed that fast flowing waters are well oxygenated and are inhabited by sensitive macro invertebrate taxa. While the lower parts of the Dams had lower flow velocity. Thus lower flow or stagnant waters have less oxygen and with abundance of tolerant macro invertebrate taxa such as Oligochaete, Chironomidae and Hirudinidea (Allan, 1995). Hence combine effects of reduced oxygen and decreased flow velocity from the upper parts to the lower parts of the Dams may have result in the sudden disappearance and replacement of sensitive macro invertebrate taxa with the tolerant taxa.

These might subsequently lower the BMWP/ASPT score in lower parts of the Dam, because tolerant macro invertebrate taxa have lower scores in the BMWP score index (Armitage *et al*., 1983).

Study by Dewdon, (2007) have indicated that sedimentation rate increase with reduced flow velocity and increased sedimentation also alter the suitability of substrate for some tolerant macro invertebrate taxa. Hence increased sediments deposits in the lower parts of the Dams due to reduced flow rate, might change the substrate composition. This might eventually result in the replacement of sensitive macro invertebrate taxa with tolerant macro invertebrate taxa and subsequently lowering of BMWP/ASPT scores. The result of this study is similar with studies by Bawa, (2014) and Donohue and Irvine (2004) which reported lower BMWP/ASPT score in the lower parts of River and Streams due reduced flow velocity and increased sedimentation.

This study revealed a total of seven macro invertebrates' species at Magaga Dam with 15 families and six macro invertebrate species with 13 families at Kanye Dam. The number of macro invertebrate families recorded in this study were higher than 9 families reported at Thomas Dam by Ibrahim and Nafiu, (2017). However, the number of macro invertebrate families was low in comparison with 21 families reported by Akaahan *et al*., (2016) in River Benue. Emere and Nasiru (2009) recorded 27 macro invertebrate families in River Kaduna and 55 were also recorded in tropical streams by John and Abdulrrahman (2014).

Aquatic beetle, Snail and Oligochaeta had the highest frequency of occurrence in both Dams and this could be due to their tolerance to organic pollution. Oligochaeta for instance have been described as deposit feeders as much more tolerant to silting and decomposition than other groups of benthic organisms (Olumukoro and Victor, 2001). The higher number of frequency of occurrence of tolerant macro invertebrates taxa recorded in this study might be associated with poor water quality and responsible for the lowering BMWP/ASPT score index.

CONCLUSIONS AND RECOMMENDATIONS

This study has proved and strengthen the suitability and practicability of the use of British Monitoring Working Party (BMWP) and its derivative the Average Score per Taxon (ASPT) as an index of organic pollution in Nigerian Water bodies. This is because BMWP/ASPT score has showed significant difference in water quality between the upper and lower parts of Dams. The BMWP/ASPT score were higher in upper parts than the lower parts of the Dams, thus indicating good water quality in the upper parts and poor water quality in the lower parts. The study attributed the effect of reduced flow rate and increased sedimentation to be the cause of this difference. However further detailed research should be carried on the use of BMWP/ASPT score index in Nigeria water, this will provide more base line information for the formulation of an adopted BMWP/ASPT score index suitable for Nigeria water bodies. It's therefore recommended that the use of BMWP/ASPT score index should be adopted in Nigeria as an effective tool for monitoring water quality.

Contribution of Authors

Usman Bawa designed the research, analyzed the data and draft manuscript. Ibrahim Abdullahi Muhammed and Hafiz Ibrahim carried out data collection, sorting and identification of macro invertebrates.

Conflict of interest

The authors declare that they do not have conflict of interest.

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