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The impact of farming on river banks on water quality of the rivers

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ABSTRACT: A study was carried out in a strip of a river in the dry and rainy seasons to assess the effect of farming along river banks on the quality of water in rivers. The results showed that there was an increase in the concentration of nitrate in the water downstream in both the rainy and dry seasons. In both rainy and dry seasons, the total nitrogen in the soil was highest ($p<0.01$) in the middle section. Significant seasonal differences ($p<0.01$) were observed for phosphate in water, being higher in the dry season. In the soil, the concentration of phosphate showed significant sectional differences ($p<0.01$) in the rainy season with the highest concentration observed in the lower section (1.74±0.01mg/l) and the least in the upper section (1.02±0.01g/l). However, in the dry season, the highest concentration was obtained in the middle section (1.69±0.01mg/l) and the least in the upper section (1.15±0.02 mg/l). The results suggest that the farms along the riverbanks have an impact on the water quality of the water in the river. It is therefore recommended that there should be close monitoring of the activities of the farms on riverbanks to minimise their impacts on the natural ecosystems that they interact with. Frequent monitoring of the water quality in the rivers relative to the farming estates should be done.

Key words: *Farming, fertilizers, river pollution, water quality, river bank*

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INTRODUCTION

Surface and ground water contamination has several known sources. However, routine agricultural applications of fertilizers and pesticides are recognized as the most significant ones (Ana and Sridhar, 2004; Mahvi, *et al.*, 2005; Krantz and Kifferstein, 2005; Subramanian, 2004). Once in the ground water, the contaminants are difficult to remove and this causes persistent water quality problems (Altman and Parizek, 1995). Worldwide concern about drinking water with nitrate arising from agricultural practices has prompted considerable scientific interest into the factors influencing nitrate leaching. Unfortunately, with increasing population, adequate food supplies can only be maintained by the use of fertilizers (Campbell, *et al.*, 1995). While grappling with the most basic water quality issues, the developing countries also have to face water quality problems posed by industrialization and chemical reliant agriculture (Fakayode, 2005). Declining water quality in the rivers poses many health hazards to the rural unsuspicious communities. Nitrates, sulphates and pesticides are of particular concern in both surface and ground water. Nitrates are reduced to nitrites in the body, which in turn, react with amines to form nitrosamines, some of the most potent carcinogens known. Methemoglobinemia is in fact the best documented health risk from nitrites. Also, high concentrations of nitrites in drinking water are fatal to infants (Weier, *et al.*, 1994). Sulphates are known to cause diarrhoea (Jackson et al., 1989). Research has also shown that agro-based pollutants can cause rapid loss of biodiversity (Mironga, 2005). Deforestation and extensive agricultural activities are reported to cause an increase in the concentration of chemical contaminants in water and the increased nutrient loads in the water bodies in turn, lead to rapid growth of aquatic plants and health complications in human beings who use the water for drinking (O'Neill, 1998). Malawi's economy is agriculture-based. While most farmers grow crops in the uplands, several others also grow their crops along rivers banks. One river, along whose banks are highly cultivated is the Likangala River, one of the biggest and most important rivers in the old capital city of Malawi, Zomba. It has its source in Zomba mountain and empties in a lake that is 40 km away. It passes through the city of Zomba, flows downwards across many villages to the lake. Communities along the river use the water from the river mainly for domestic purposes like cooking, drinking, washing and bathing. The river is also used for fishing and agricultural purposes. Also along the riverbank is a rice scheme, comprising three farms that irrigate the crop fields and nursery beds using the water from the river. The farms prepare the nursery beds close to the river. The proximity of the nurseries to the river means that the vegetation along the river is cleared to accommodate the nurseries. Pollution of the water in the river and depleting its resources can put the lives of many people in danger. Unfortunately, there is no information on the effect of the farming activities along the rivers on water quality of the water in those rivers. Such information is vital for the policy makers who should in turn, give proper advice to the farm owners and the communities for the good of their health. The objective of this work was therefore to assess the chemical pollution of the water in the rivers whose banks are highly cultivated. Specifically, the study was carried out to determine the nitrate, phosphate and total nitrogen loads in the river water and river sediments. The study was carried out in a river (Figure 1) that runs through the old capital of Malawi, Zomba in the dry season (October) and rainy season (January) in 2004. The part of the river studied was divided into three sections, about 5 kilometres apart as the upper, middle and lower sections.

MATERIALS AND METHODS

The study was carried out in a river (Fig. 1) that runs through the old capital of Malawi. The part of the river studied was divided into three sections, about 5 kilometres apart as the upper, middle and lower sections.

Samples were collected from points A, B and C of the upper, middle and lower sections (Fig. 1), respectively. These sites were sampled in the rainy and dry seasons. Twenty water samples and twenty soil samples were collected from each section of the river in each season.

The folloeing analysis were carried out as follows:

Total nitrogen: This was determined by calorimetric methods (AOAC, 2002). A soil sample was first extracted with Merlinch-3 solution (Mughogho, 2004, Personal communication). To a 400ml sample of extract was added 100ml of digestion solution, mixed and then boiled until the solution became colourless. After cooling, the resulting solution was diluted with 300ml of distilled water after which a NaOH-$Na_2S_2O_3$ solution was added until the solution was alkaline. The mixture was digested in a kjelhahl flask with the distillate being collected in an Erlenmeyer flask. To 50ml of distillate was added Nessler reagent (1ml) and mixed. After standing for 20 minutes, the absorbance was read at 425 nm. Another 50 ml sample was prepared as above and its absorbance read. The concentration of ammonia-nitrogen was obtained from a standard curve. The total nitrogen was then obtained as mg total N/l = {mg NH_3-N 1000/ml sample}× {ml final distillate/ml distillate taken for nesslerrization}.

Phosphate: This was determined by calorimetric methods (AOAC, 2002). A soil sample was first extracted with Merlinch-3 extraction solution (Mughogho, 2004 personal communication) and the filtrate was then used for analysis of phosphate. To 50ml of extract was added hydrolysing acid (1 ml) followed by a combined reagent (8 ml) and mixed. After standing at room temperature for 20 minutes, the absorbance of the solution was read at 880nm and the concentration of phosphate obtained from a calibration curve.

Nitrate: This was determined by calorimetric methods (AOAC, 2002). To a 10 ml sample in a sample tube was added sulphuric acid, (13 N, 10 ml). The tube was then placed in a water bath at 10^{o}C for 3 minutes after which, brucine reagent (0.5 ml) was added. The tube was placed in boiling water bath for 25 minutes and then cooled to room temperature. The absorbance of the sample was measured at 410nm using a spectronic 21D calorimeter and the amount of nitrate obtained from a calibration curve.

pH: A pH meter was used to determine the acidity of the samples.

Data was analysed using Statistical package for Social Sciences (SPSS) Program to find the mean concentrations. The paired t-test was used to compare the sectional concentrations as well as the seasonal differences in concentrations of the parameters determined.

RESULTS

Table 1 shows the parameters obtained in the water in the rainy and dry seasons in the upper, middle and lower sections of the river (Fig. 1). In the rainy season, the pH was 6.9±0.01 in the upper section, 5.8±0.02 in the middle section and 5.8±0.05 in the lower section. The concentration of nitrate was 0.18±0.01 mg/l in the upper section, 0.25±0.02 mg/l in the lower section and 0.39±0.02 mg/l in the lower section. The concentration of phosphate was 0.08± 0.05 mg/l in the upper section, 0.13±0.07 mg/l in the middle section and 0.12±0.05 mg/l in the lower section. In the dry season, the pH was 6.8±0.02 in the upper section, 5.5±0.05 in the middle section and 5.9±0.02 in the lower section. The concentration of nitrate in this season was 0.16±0.01 mg/l in the upper section, 0.20±0.02 mg/l in the middle section and 0.28±0.01 mg/l in the lower section. The concentration of phosphate was 0.16±0.07 mg/l in the upper section, 0.20±0.04 mg/l in the middle section and 0.19±0.05 mg/l in the lower section. The parameters obtained in the soil sediments in the rainy and dry seasons from the three sections of the river are given

Table 1: pH, nitrate and phosphate levels in the water in the rainy and dry seasons

Section of river	Rainy season			Dry season		
	pH	NO_3^- (mg/l)	PO_4^{-3} (mg/l)	pH	NO_3^- (mg/l)	PO_4^{-3} (mg/l)
Upper	6.9±0.01	0.18±0.01^a	0.08±0.05^a	6.8±0.02	0.16±0.01^a	0.16±0.07
Middle	5.8±0.02	0.25±0.02^b	0.13±0.07^b	5.5±0.05	0.20±0.02^a	0.20±0.04
Lower	5.8±0.05	0.39±0.02^c	0.12±0.05^b	5.9±0.02	0.28±0.01^b	0.19±0.05

$^{a-c}$Means with the same letter in a column are not significant at P=0.01

Table 2: pH, total nitrogen and phosphate levels in the soil in the rainy and dry seasons

Section of river	Rainy season			Dry season		
	pH	Total N (mg/l)	PO_4^{-3} (mg/l)	pH	Total N (mg/l)	PO_4^{3-} (mg/l)
Upper	5.6±0.03	0.72±0.01^b	1.02±0.01^b	5.7±0.05	0.98±0.02^a	1.69±0.01^a
Middle	5.8±0.03	1.16±0.01^a	1.49±0.05^{ab}	5.6±0.05	0.73±0.02^b	1.15±0.02^c
Lower	5.7±0.05	0.9±0.02^b	1.74±0.05^a	5.5±0.04	0.72±0.04^b	1.38±0.01^b

$^{a-c}$Means with the same letter in a column are not significant at P=0.01

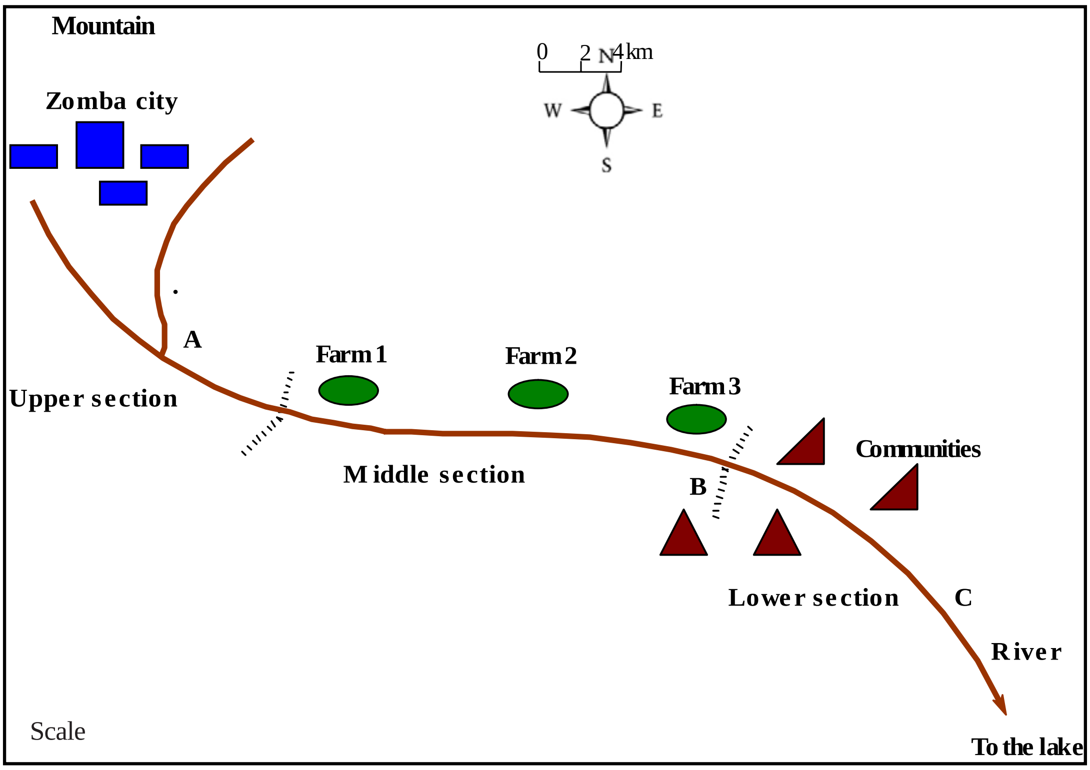

Fig. 1: Sections of the river from which samples were collected

in Table 2. In the rainy season, the pH was 5.60.03 in the upper section, 5.8±0.03 in the middle section and 5.7±0.05 in the lower section. The total nitrogen in the same season was 0.72±0.01 mg/l in the upper section, 1.16±0.01 mg/l in the middle section and 0.90±0.02 mg/l in the lower section.

The concentration of phosphate was 1.02±0.01 mg/l in the upper section, 1.49±0.05 mg/l in the middle section and 1.74±0.05 mg/l in the lower section. In the dry season, the pH was 5.7±0.05 in the upper section, 5.6±0.05 in the middle section and 5.5±0.04 in the lower section. The total nitrogen in this season was 0.98±0.02 mg/l in the upper section, 0.73±0.02 mg/l in the middle section and 0.72±0.04 mg/l in the lower section. The concentration of phosphate was 1.69±0.01 mg/l in the upper section, 1.15±0.02 mg/l in the middle section and 1.38±0.01 mg/l in the lower section.

DISCUSSION AND CONCLUSION

The concentration of nitrate in the rainy season was highest ($p<0.01$) at the lower section of the river and least in the upper section. However, the trend was different in the dry season.

There were significant differences ($p<0.01$) between the lower and the other two sections but no difference was observed between the upper and the middle sections. Seasonal differences were significant at the upper section only, the concentration being higher in the rainy season compared to that in the dry season. However, all concentrations were much lower than the limit set by the Malawi Bureau of Standards (100 mg/l) in drinking water (MBS, 2000). Studies by Altman and Parizek (1995) on sloping agricultural land also showed that while the concentration of nitrate was high in cropping area, it was low or none in the stream. This was explained as being due to dilution as the water discharged into the stream. The other reasons given were that of dinitrification and plant assimilation of the nitrate before it went into the river. It was stated that on sloppy land, ground water could be forced to flow close to the ground before discharging into the stream and it was on this shallow area that denitrification and plant assimilation were most likely to remove nitrate. This explanation may also apply in this study. In addition, in the warmer seasons, nitrate levels are likely to be reduced by biochemical processes and by algal assimilation. In Malawi, temperatures are high in the dry season and this increases the biochemical activities in the water. Since there is no surface runoff into the river, the concentration of nitrate is reduced much more. In absolute terms though, the concentrations were higher in the rainy season than in the dry season.

The highest concentration of phosphate in the dry season was obtained in the middle section. The upper section had the lowest concentration of phosphate in absolute terms followed by that in the lower section. These values were higher than the value given for natural water bodies (O'Neill, 1998). Although there were no significant differences in the concentration of phosphate during the dry season, the trend showed that higher levels were found in the middle and lower sections. In the rainy season, the concentration of phosphate in the upper section was significantly different ($p<0.01$) from that in the lower section or that in the middle section. The results showed that the phosphate concentrations were within the WHO recommended values (0.05-0.1 mg/l). Significant seasonal differences ($p<0.01$) in the concentration of phosphate in water were observed in the lower section only, being higher in the dry season than in the rainy season. This trend was opposite to that observed for nitrate. In general, the highest concentrations were obtained in the lower and middle sections and the least in the upper section. The higher concentrations observed in the middle and lower sections in the two seasons suggest that the farming estates might contribute to the phosphate load of the river during the rainy season. In the soil, the upper section had the highest concentration of phosphate in the dry season while the least concentration of this ion in the same season was in the middle part. This pattern of the concentration of phosphate in the soil in the dry season was in contrast to that observed in water. However, during the rainy season, the concentration of phosphate increased downwards, being highest ($p<0.01$) in the lower section and the least in the upper section. This could suggest that during the dry season, there was not much phosphate discharged into the river whereas during the rainy season, most of it was discharged probably due to surface runoff from the crop fields. The higher concentration of phosphate in the lower section of the river could also be due to the fact that the eroded soil from the farming estates did not immediately settle within the middle section due to high volume and flow rate of water in the river during the rainy season. These results agree with those of other researchers (Altman and Parizek, 1995), who also noted that when ground water discharges into streams and rivers, the water quality problems tend to accumulate at the lower end of the basin. Both sectional and seasonal differences were highly significant ($p<0.01$). The concentration of phosphate in the river was higher than 0.01mg/l during both the rainy and dry seasons. This meant that there was likely to be a continuous algal growth through out the year, other factors being constant. It was however observed that the algae were very common mostly during the dry season and this was probably because the flow rate of the water in the river was low. During the rainy season, there was growth of some higher aquatic plants that were able to withstand the high flow rate of the water. The pH of the soil did not differ significantly between the sections and also between the seasons. The highest concentration of total nitrogen in the soil was obtained in the upper section during the dry season and this was much higher ($p<0.01$) than the concentrations obtained in the middle and lower sections. However, during the rainy season, the highest concentration was obtained in the middle section and the least was in the upper section. The amount of nitrate in the water obtained in the middle and lower sections during the rainy season relative to the total nitrogen in these sections may suggest that the agricultural activities on the estates might have an effect on the concentration of this substance. However, nitrate salts being so soluble, could easily be moved downstream accounting for the higher concentration in the lower section of the river. On site observations showed that farms 1 and 2, which are located on the upper and lower sections of the study area respectively, do not have any structures to protect or minimise runoff into the river. It was observed that there was an indiscriminate cutting down of trees along the river in these areas and this resulted in rapid soil erosion. On the other hand, farm 3, which is in the middle section, had a well-established disposal site for the chemical containers. The disposal site was situated at about 2 kilometres away from the nursery site. The riverbank of this section was fully under forest cover and there were strict measures against the cutting down of trees along the river. There was controlled use of the water such that the water flowing back into the river was minimised. However, when tobacco seedlings were removed from the nurseries, the area was left uncontrolled. This probably led to the movement of residual nutrients into the river during the rainy season. In general, there were not enough management systems to prevent the runoff from the nurseries and crop fields close the river from entering the river system. While this work was carried out only in one river as most such work are (Fakayode, 2005; Mahvi et al., 2005), it gives an insight into what also happens in other worldwide rivers whose banks are cultivated. Consequently, close monitoring of the water quality of the waters in these rivers should be encouraged by all concerned. The results have shown that there was an increase in the concentration of nitrate downstream during both the rainy and dry seasons. In the rainy season, significant differences in the concentration of nitrate were observed between sections. In the dry season, the differences were only observed between the lower and the other two sections. The total nitrogen in the soil was highest in the middle section in both the rainy and dry seasons. Sectional and seasonal differences were not observed for phosphate although in absolute terms, the middle and lower sections had higher concentrations. In the soil sediments sectional differences in the rainy season were significant with higher concentrations obtained in the upper section and the least in the middle section. Although the concentrations of the parameters obtained were below the allowable limits, these results suggest that the farms along the river have an impact on the water quality of the water in the river. The poor management practices of the farms could be a major contributing factor. It is therefore recommended that there should be close monitoring by the relevant authorities of the activities of the farms to minimise their impact on the natural ecosystems that they interact with. There should also be frequent monitoring of the water quality in the river so as to protect the lives of the people who use the water for domestic use.

REFERENCES

Association of Official American Chemists, (2002). Official methods of analysis, 17th. Ed. Association of Official Analytical Chemists, Maryland, USA.

Altman, S. J. and Parizek, R. R., (1995). Dilution of non-point source nitrate in ground water. J. Environ. Qual., ***24****, 707-718.*

Campbell, C. A., Lafond, G. P., Zentner, R. P. and Jame, Y. W., (1994). Nitrate leaching in udic haploboroll as influenced by fertilization and legumes. J. Environ. Qual., ***23****, 195-201.*

Eana, G. R. E. and Sridhar, M. K. C., (2004). Soil quality near chemical fertilizer industry at Port Harcourt, Nigeria. African J. Environ. Ass. and Mgt. ***8****, 19-26.*

Fakayode, S. O., (2005). Impact assessment of industrial effluent on water quality of the receiving Alaro River in Ibadan, Nigeria. African J. of Environ. Ass. Manag., ***10****, 1-13.*

Jackson, M. H., Morris, P. G., Smith, P. G. and Crawford, J. F., (1989). Environmental health reference book, ***9****, 1-22.*

Krantz, D. and Kifferstein, B., (2005). Water pollution and Society. Available at www.umich.edu.

Malawi Bureau of Standards (MBS), (2000). MBS guidelines on constituents of health significance, MBS, Malawi.

Mahvi, A. H., Nouri, J., Babaei, A. A. and Nabizadeh, R.,(2005). Agricultural activities impact on groundwater nitrate pollution. Int. J. Environ. Sci. Tech., ***2*** *(1), 30-35.*

Mironga, J. M., (2005). Conservation related attitudes of wetland users in Kisii District, Kenya. African J. of Environ. Ass. Manag., ***10****, 14-25.*

Mughogho, S., (2004). Personal communication, University of Malawi, Bunda College of Agriculture.

O'Neill, P., (1998). Environmental Chemistry, Blackie Academic and Professional Pub. London, UK.

Subramanian, V., (2004). Water quality in South Asia. Asian J. water, environ. pollut., ***1*** *(1-2), 41-54.*

Weier, K. L., Doran, J. W., Mosier, A. R., Power, J. F. and Peterson, T. A., (1994). Potential for bioremediation of high nitrate irrigation water via denitrification. J. Environ. Qual., ***23****, 105-110.*