Water and Soil Quality in the Vicinity of a Vegetable Oil Producing Company and a Poultry Hatchery

M. M. Mauluka[1], G. Mmangisa[1], P. Mumba[2,*] and B. Moyo[1]

[1]*Environmental Science Department,* [2]*Basic Sciences Department, Lilongwe University of Agriculture and Natural Resources, P.O. Box 219, Lilongwe, Malawi*

Abstract: In the vicinity of two factories, one a vegetable oil company and a poultry hatchery lives a farming community. The crops in the community's fields have either not been germinating or dying before reaching maturity. A study was therefore conducted to assess the quality of effluent discharged into a stream, water in the stream and in the soil in the surrounding fields. Both the effluent and the water at selected points in the stream were analyzed for some parameters in the dry and rainy seasons. In the soil, pH, phosphorus, organic matter, soil respiration, electrical conductivity and nitrogen were analyzed only in the dry season. The results showed that the effluent and the water at all points sampled were slightly acidic in both the dry season and wet season. The dissolved oxygen was low in dry season but was relatively high in rainy season. The electrical conductivity and total dissolved solids had high concentrations in both seasons. Phosphate was high in the effluent in both seasons. The water upstream had higher levels of dissolved oxygen than at all points down the stream in both seasons. Oil was higher in dry season ($p<0.05$) than in rainy season although upstream water recorded low levels in this season. In the soils, high values of phosphorus, electrical conductivity and oil were observed in the lower slope field as compared to the upper slope field. Soil respiration was also low in the lower slope field. The results have shown that spillage and concentration of the effluents on the lower slope field may have had an effect on the soils which in turn affected the crops in that part of the field as had been observed by the communities.

Keywords: Vegetable oil, effluent, pollution, stream water, field soil.

1. INTRODUCTION

There is a growing interest worldwide with regard to the use of renewable energy sources as a means to both reduce environmental pollution associated with energy produced by fossil fuels and to tackle the problem of the depletion of these fuels [1]. Vegetable oil has been presented as possible energy source with more ecological benign hence emerges as an alternative to non-renewable resources with higher pollution potential [2]. However, this alternative energy source only gained focus after the petroleum crisis in 1970s and currently, its production and use has increased in many countries worldwide [1]. Edible-grade vegetable oils are produced mainly from soybean, rapeseed, sunflower and groundnuts.

In contrast, increased production and consumption of vegetable oil has contributed to an increase in the amount of waste substances being produced [3]. Reports have shown that pollution from vegetable oils deposed in the environment can have damaging effects in ecosystems and on plants and animals through suffocation and inhibition of feeding [1, 4-7]. A study on the effects of vegetable oil pollution on aquatic macro invertebrate assemblage showed that certain macro invertabrates tolerate oil spills and these could be used as indicators of vegetable pollution [8]. The oils may also leach to the groundwater [9]. Results of the environmental life cycle assessments of the various vegetable oils showed that sunflower oils had high impact burdens on crop production than either rapeseed, olive or other oils [10]. This was also concurred by results of a study which showed that sunflower oil had adversely affected the growth of A. sativa. In addition the sunflower oil decreased the soil pH [11]. Previous studies on the effect of industrial effluents on water quality of rivers have revealed excessive pollution of the water in streams [12].

In Malawi there is a vegetable oil producing company and poultry hatchery that is located near some villages. The effluents from the factory are discharged through channels into a stream from which the villagers draw water and catch fish. On both sides of the stream the community grows crops such as maize, bananas, beans and others. Naturally companies are supposed to treat the effluents before discharging them. Unfortunately, the communities in the surrounding area noticed that their crops were failing to germinate or those that germinated were wilting or even dying before reaching maturity. Those that reached close to maturity stage could not produce or mature well. The farmers had also observed a decrease in yields on the lower slope side of the fields where the effluents had probably spilled over compared to the higher side that was little affected by the effluents. It was therefore necessary to assess the quality of the water and the soils in the fields for possible contaminants.

*Address correspondence to this author at the Basic Sciences Department, Lilongwe University of Agriculture and Natural Resources, P.O. Box 219, Lilongwe, Malawi; Tel: (265) 995627462; E-mail: mumbap01@yahoo.com

E-ISSN: 2311-8741/18

The objective of this study was therefore to assess the quality of the water in the stream and also the soils on the upper and lower sides of the stream for any pollutants that could affect crop production in the area.

2. MATERIALS AND METHODS

2.1. Study Area and Sampling Method

The area has two companies, one is a poultry hatchery and the other one is a vegetable oil factory (Figure **1**). The effluents are discharged through two separate channels one from the poultry company and the other from the vegetable oil company. The effluents meet and enter a single channel before entering the Stream. The stream is very significant to the socio-economic growth of communities around the area as it supplies the basic water needs. It also serves as a source of water for agricultural activities and most importantly fishing. The whole area is on a slope and the stream runs along this slope such that during the rainy season the effluents spill over to the lower side of the slope while just a little go on the upper side. Samples of effluents were collected just before they were discharged into the stream for analysis of parameters at the laboratory. Water samples were collected from the stream on upper part, at the point where effluents were discharged and the third ones on the lower part of the stream. Soil samples were collected from the lower part and upper parts of the slope along the stream. The fields were divided into several sub-locations from where ten sub-locations were selected. From selected ten, two composite samples were collected from five sub samples to get to the samples. Soil sampling was done only during dry season when the disturbance to the soil is minimal [13]. For mobile nutrients like nitrogen, sampling was done in the morning or late afternoon when the biological activities in the soil are low so as to avoid further changes in the nutrient level. An auger was used to collect soil samples at different depth, type and location. Finally, samples from each location were quartered after which 5g were obtained and placed in sealed sampling bags and taken to the laboratory for analysis. Only mean values were taken for soils samples.

Different sampling depth was used depending on type of soil parameter. For mobile nutrients like nitrogen, a depth of 0-22 and 22-45 cm or tillage depth sample was used for the samples were taken from a ploughed land. Samples from 0-20cm depth were collected for organic matter and pH determination. Soil samples from 0-10cm were collected for determination of levels of vegetable oil in the soil. Each sample from different sampling depth was placed in separate sample bags, labeled and taken from each replicate treatment and plot.

2.2. Analysis

2.2.1. Microbial Biomass

A moist soil sample (10g) was put in 50ml beaker which was then placed in a plastic bottle containing 20 ml NaOH. The bottle was closed tightly and incubated

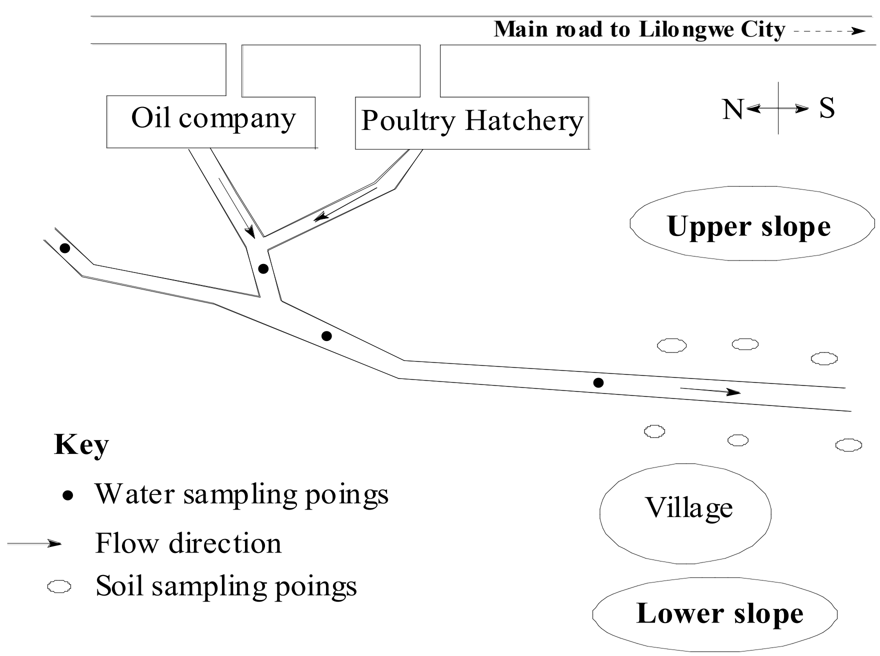

Figure 1: Study area showing sampling points for water and soil samples.

for 48 hrs at 22°C after which 2 ml $BaCl_2$ solution was added. Diphenyl amine indicator (3 drops) was added and the solution was back titrated with 0.1M HCl. A control was also prepared without the soil. The respiration rate was derived from the amount of the HCl consumed by the soil samples. The amount of carbon dioxide produced was calculated from the equation:

$$CO_2 \text{ production rate} = \frac{(B-S) \times 22/(No.\ of\ days\ incubated\ )}{kilograms\ \ of\ dry\ soil}$$

Where: B = Blank value, S = Sample value.

2.2.2. pH

This was determined directly in stream water using a pH meter. For soils, a dry soil sample (50g) was weighed and placed in 50 ml beaker and distilled water (100ml) was added stirred and allowed to stand for 30 minutes. pH was measured from the suspension.

2.2.3. Dissolved Oxygen

The dissolved oxygen was measured directly using a DO meter A water sample (50ml) from the four sampling points were transferred into a beaker for DO measurements.

2.2.4. Temperature

Temperature of both the effluent and the stream water was measured directly using a thermometer.

2.2.5. Total Dissolved Solids

This was measured directly using the TDS meter.

2.2.6. Phosphate

To a 50 ml. sample was added 8ml. of combined reagent (a mixture of solutions of sulphuric acid, potassium antimony tartrate, ammonium molybdate and ascorbic acid), mixed and left to stand for 10 minutes. The absorbance of the solution was measured at 880 nm and the concentration of phosphate obtained from a calibration curve [14].

2.2.7. Organic Matter

A dry soil sample (1g) was placed in 500 ml flask and 1N potassium dichromate (1ml) then was added and thoroughly mixed. Concentrated sulphuric acid was added to the mixture and gently mixed by rotation for 1 minute. The solution was allowed to stand for 30 minutes after which distilled water (100ml) was added. The solution was then titrated with 0.5N ammonium ferrous sulphate to a clear blue colour using diphenylamine indicator. Organic matter content was calculated from the equation:

$$\%\ \text{Organic matter} = \frac{(B\text{-}S) \times 0.5 \times 0.003 \times 100 \times 1.3 \times 1.724}{\text{Soil sample weight}}$$

Where: B = blank value.

S = value of the sample.

1.3 = % total carbon.

2.2.8. Nitrogen

A soil sample (0.2g) was weighed and placed in centrifuge tube. Mehlich solution (25ml) was added and the mixture shaken for 5 minutes after which, it was filtered. The filtrate was placed in a vial into which was poured 5 ml each of N1 and N2 working solutions that were previously prepared and mixed [14]. The solution was allowed to stand for 30 minutes after which, absorbance was measured at 655 nm on a UV spectrophotometer. A blank was also run. The percentage nitrogen was obtained from:

$$\%\ \text{N in the soil} = \frac{(\text{Smp. N conc mg/l} - \text{N blnk conc. mg/l}) \times 0.0001 \times 50\text{ml}}{0.2\text{g}}$$

Where, Smp. N conc = concentration of the sample.

Nblk conc. = concentration of the blank.

2.2.9. Vegetable Oil

Oils in water were determined by extracting with petroleum ether [14]. To a 50 ml sample was added petroleum ether (20 ml) and shaken for 10 minutes. The ether layer was decanted and evaporated leaving the oil which was then weighed. For the soils, a 5g was placed on a previously weighed filter paper and properly covered. This was placed in a beaker containing 20 ml petroleum ether and left to stand for 48 hours. The filter paper plus the soil was removed and the ether was then evaporated off. The weight of the beaker and the oil was recorded and the percentage of the oil calculated.

2.2.10. Electrical Conductivity

Electrical Conductivity in the water samples was determined directly in the water by a conductometer [14]. An air dry soil sample (50g) was weighed and put into 50 ml beaker after which distilled water (100 ml) was added, stirred and allowed to stand for 30 minutes. The conductivity was then measured from the suspension.

2.3. Data Analysis

Data was analysed using Genstat package. T-test and Analysis of Variance were used to separate the means.

3. RESULTS

Table **1** shows the concentrations of the parameters obtained in the effluent and stream water sampled in the rainy season, Table **2** shows the concentrations obtained in the effluent and stream water in the dry season and Table **3** shows parameters obtained in the soil in the dry season. In the dry season, the effluent pH was 5.1±0.1 and in the rainy season, the value was 4.9±0.23. In the effluent, dissolved oxygen (DO) in the rainy season was 6.7±2.90 mg/l and in the dry season, the value was 1.10±0.07 mg/l. The electrical conductivity (EC) in the effluent was 528.2±183 µS/cm in the rainy season and 2498.0±21.07µS/cm in the dry season. Total dissolved solids were 611±156 mg/l in rainy season and 2593.3±69.3 mg/l in the dry season in the effluent. The concentration of phosphate in effluent in the rainy season was 2.5±0.1 mg/l and 4.7±3 mg/l in dry season. The oil and grease in the effluent was 2.7±0.12 mg/l in the rainy season and in dry season the level of oil and grease was 497.7±26.1 mg/l. The temperature of the effluent was 27.3±0.06 ^{o}C in the dry season and it was 22.5±3.7 ^{o}C in the rainy season.

In the dry season, the pH levels were 6.1±0.05 upstream, 5.4±0.2 at the discharge point, and 5.2±0.1 downstream while in the rainy season the values were 6.5±0.7 upstream, 4.9±2.3 at the discharge point, and 6.2±0.6 downstream. The dissolved oxygen (DO) at upstream was high in wet season (10.7±3.5 mg/l) and the dry season (6.3±0.5 mg/l). While the values were slightly higher in the rainy season at the discharge point (6.8±1.3 mg/l) and downstream (10±2.8 mg/l), they were lower at both points in the dry season. The electrical conductivity (EC) was 478.7+48.5 µS/cm upstream, 1151.7±113.8 µS/cm at the discharge point and 1085.0±11.5 µS/cm downstream in the dry season. In the rainy season, the electrical conductivities ranged from 293.5±95.7µS/cm downstream to 528.2±183 µS/cm at the discharge point. In the dry season, the

Table 1: Mean Parameters Obtained in the Effluent and Stream Water in the Wet Season

	DO (mg/L)	EC (µS/cm)	TDS (mg/L)	pH	Oil (mg/L)	Phosphate (mg/L)	Temp (^{o}C)
Effluent	6.7±1.3	528.2±183	611.0±156.6	4.9±2.3	2.7±0.12	2.5±0.1	22.5±3.7
Water							
Up stream	10.7±3.5	397.6±166.7	467.7±141	6.5±0.7	1.7±0.4	1.7±0.7	22.1±3.2
Discharge point	6.9±1.3	528.2±183	611.0±157	4.9±2.3	2.7±0.5	2.5±1.9	22.5±3.4
Down stream	10.0±2.8	293.5±95.7	314.3±33	6.2±0.6	2.4±0.7	1.2±0.5	20.8±1.0

Table 2: Mean Parameters Obtained in the Effluent, Water and the Soil in the Dry Season

	DO (mg/L)	EC (µS/cm)	TDS (mg/L)	pH	Oil (mg/L)	Phosphate (mg/L)	Temp (^{o}C)
Effluent	1.10±0.07	2498.0±21.1	2593.3±69.3	5.1±0.1	497.7±26	4.7±3	27.3±0.06
Water							
Up stream	6.3±0.05	478.7±48.5	554.3±84.31	6.1±0.1	1.7±0.4	1.2±0.9	26.0±1.1
Discharge point	1.4±0.03	1151.7±113.8	1235.3±113	5.41±0.2	487.7±38	2.5±1.8	26.5±0.05
Down stream	1.4±0.03	1085.0±11.5	1170.7±12	5.2±0.1	468.0±9.5	2.0±1.6	24.9±2.7

Table 3: Mean Parameters Obtained in the Soil in the Dry Season

Site	Phosphate (mg/L)	EC (µS/cm)	Soil Respiration Kg/day/ha	Oil (mg/L)	pH	Organic Matter (%)	Nitrogen (%)
Upper slope	47.8±13	30.92±3.7	1.51±0.02	216±6.0	6.1	5.8±0.3	0.29±0.10
Lower slope	100.95±10.8	117.20±28.7	0.83±0.05	58600±233	5.2	6.0±0.2	0.36±0.10

levels of total dissolved solids were 554.3±84 mg/l upstream, 1235.3±113 mg/l at the discharge point, and 1170.7±12 mg/l downstream and in the rainy season these were 467.7±141 mg/l at upstream, 611.0±157 at the discharge point, and 314.3±33 mg/l downstream.

The concentration of oils in water in the rainy season was 1.7±0.4 mg/l upstream, 2.7±0.45 mg/l at the discharge point, and 2.4±0.7 mg/l downstream. In the dry season the values were 1.7±0.4 mg/l, 487.7±38 mg/l, and 468.0±9.5 mg/l at these points respectively. The concentration of phosphate in the dry season was 1.2±0.9 mg/l upstream, 2.5±1.8 mg/l at the discharge point, and 2.0±1.6 mg/l downstream. In the rainy season, the values were 1.7±0.7 mg/l upstream, 2.5±1.9 mg/l at the discharge point, and 1.2±0.5 mg/l downstream. The temperatures were 24.9±2.7^{o}C downstream, 26.5±0.05^{o}C at the discharge point in dry season and 20.8±1.0^{o}C and 22.5±3.4^{o}C at these points respectively in the rainy season.

In the soil, phosphorus was 47.8±13 mg/l in the upper slope while the concentration was 100.95±10.8 mg/L on the lower slope. The electrical conductivity was 30.92±3.7 µS/cm on the upper slope and 117.2±28.7 µS/cm on the upper slope. Soil respiration was 1.51±0.02 kg/day/ha on the upper slope and 0.83±0.05 kg/day/ha on the lower slope. The amount of oil was 216±6 mg/l on the upper slope and 58600±233 mg/l on the lower slope. The pH of the soil was 6.1 on the upper slope and 5.2 on the lower slope. Organic matter content was 5.8±0.3% on the upper slope and 6.0±0.2% on the lower slope. The nitrogen content was 0.29±0.1% in the upper slope and 0.29±0.10% on the lower slope.

4. DISCUSSION

The parameters along the stretch of the stream showed variations of concentrations across the sampling sites and within the two seasons. Upstream, the value was slightly higher in both seasons than either in the effluent, at the discharge point or downstream. Lowest pH ($p<0.05$) was obtained in the effluent and at the discharge point in the rainy season compared the values at the same points in the dry season. In both seasons, the pH was below 7 which suggested that the effluent probably the vegetable oils had some effect. A similar observation on the effect of vegetable oils on pH has been made by other researchers [8]. The low pH levels could be due to high presence of wastes such as phosphoric or citric acid used in converting non-hydrolysable phospholipids when refining vegetable oils.

The pH of the soil was higher in the upper slope field compared to that in the lower slope. This means that the soil is moderately acidic in the lower slope field area and almost neutral in the upper slope field area. This could be due to the fact that vegetable oils have fatty acids in them. Different plants respond differently to soil pH, some plants grow well over a wide range of pH, whilst others are very sensitive to small variations in acidity or alkalinity. Soil pH of 5.2 to 8.0 provides optimum conditions for most agricultural plants. Acidity conditions may lead to the problem of aluminum toxicity, which occurs when aluminium bound to soil constituents, particularly clay particles and organic matter becomes soluble and the amount of aluminum in the soil solution increases and affects the availability of nutrients to crops. Microbial activity in the soil is also affected by soil pH with most activity occurring in pH of 5.0 to 7.0. Where the extremities of acidity or alkalinity occur, various species of earthworms and nitrifying bacteria disappear. Legume root colonizing bacteria (*Rhizobia*) vary in their sensitivity to soil pH and have preferred ranges in which they are effective. In some crops and pastures such as faba beans and Lucerne, the *Rhizobia* specific to these plants are more sensitive than the plant itself [15]. This could therefore explain why crops were not doing well in the lower slope field before they reach maturity compared to those in the upper slope field.

Dissolved oxygen differed significantly ($p<0.05$), being lowest in effluent at the discharge point and downstream compared to values upstream in the dry season. In the wet season the values upstream and downstream were also high. The values in the effluent and at the discharge point although higher that at the same points in the wet season were low. The slightly lower DO level at the discharge point in the dry season could be due to the nature of the effluent that was released immediately before that point. The effluent discharged had a level of 1.09 mg/l., which suggested that the industries were releasing some organic substances that were high oxygen-demanding wastes [16]. The level increased level downstream could be due to the large number of plants near this point which might have helped to increase flow of water which in turn helped aeration of the water. Lower values obtained in the dry season could be due to low level of dilution rate as a result of low water volume during dry season with little self-purification process of the pollutants. The high value downstream in the rainy season might signify the recovery of the stream. In all, dissolved oxygen levels observed downstream in dry season were below the 10 mg/l recommended for unpolluted waters and the values obtained at the same point in wet season were far greater than 6.0mg/L recommended for drinking [17].

There was significant variation in total dissolved solids ($p<0.05$) between effluent samples in dry and wet season. The total dissolved solids were highest in the effluent in dry season than in rainy season. The higher values in the dry season could be due to wind erosion from the surrounding farm areas that might have brought in ionic substances such as nitrates, chlorides and phosphates adsorbed in the soil particles [18]. Significant variations $p<0.05$) were also observed between the stream and effluent samples in both dry and rainy season. Higher values were obtained in water samples in dry season than in wet season. The lower levels in the wet season could be as a result of dilution effect of the rainy water. The levels in both were way above the acceptable limit for drinking [19, 17].

The electrical conductivities were higher ($p<0.05$) at the discharge point and downstream in the dry season. The higher conductivities observed at these points could be due to the relatively low dissolved oxygen and high total dissolved solids in the effluents coming from the industries. However, in the rainy season, the electrical conductivities were lower than those observed in the dry season. This could be attributed to dilution of salts arising from increased water volume in the river. Significant differences ($p<0.05$) between sampling points were also observed. Nevertheless, the electrical conductivity of the stream was beyond the set limit of 150 μS/cm by the Malawi Bureau of Standards [19] in both seasons. In the soil, the EC was also higher in the lower slope than in the upper slope. This could be due to the addition of sodium hydroxide as a catalyst during hydrogenation of the oil when it is being manufactured. Ionic toxicity occurs when concentrations of salts are imbalanced inside cells and inhibit cellular metabolism and processes. Sodium ions at the root surface disrupt plant nutrition of the similar cation potassium by inhibiting both potassium uptake and enzymatic activities within the cell. Potassium is an important nutrient in a plant, regulating over 50 enzymes [20]. Essential for maintaining cell turgor pressure, creating membrane potential, and regulating enzymatic activities, potassium must be maintained at 100-200 mM in the cytosol. It is reported that when a plant senses salt stress through trans-membrane proteins or enzymes in the cytosol, the amount of calcium in the cytosol increases [20]. Calcium is a second messenger important to many biochemical pathways and can aid plants in responding to salt stress. The osmotic and ionic stress induced by salinity can halt plant growth as the plant focuses its energy on conserving water and improving ionic balance. These effects could also contribute to drying up of crops in the field.

High temperature recorded in dry season in the effluent coincided with the dry period of the year. Significantly high temperature was found to be seasonal dependent. The low values obtained in the rainy season could be attributed to the cooling effects of the rain water during this time of the year.

The values of phosphate of effluent and the values of river samples showed significant variation ($p<0.05$) between effluent and stream samples. The values in the effluent in both seasons were higher than the values at discharge point, up stream and downstream. This implied that the major phosphate in the river were from the effluents themselves. The value of downstream was higher than the upstream value indicating possible non-recovery of the stream at the point from impact of phosphate discharges from effluents. This may imply that the effluents from the factories were contributing factors of this parameter to the river. The results showed that the concentration of phosphate was significantly above the WHO standard of 0.5 mg/L in both rainy and dry season [17]. Considering the levels of phosphate reported in this study, eutrophication may be a problem especially during treatment as filter clogging may occur [21]. In addition, the growth of blue-green algae could release toxic substances (*cyanotoxins*) into the water system [22].

The amounts of oil ineffluent, stream water at the discharge point and downstream were lower in the rainy season than in the dry season. Upstream the values were low in both seasons. It is difficult to speculate the reasons for this but it could probably be due to the fact that in the dry season, there is no running rain water in the channel and in the stream and so most of the effluents along the channel and in the stream are from the effluents alone. The static water in the stream means that there is continuous accumulation of the oils in the river such that when the rains come some of these oils spill over to the surrounding fields especially on the lower slope side. The result of this spillage is the high oil levels observed in the soils on the lower slope side compared to the higher slope side. The excessively high levels of oil in the lower slope field could affect the ability of the plant nutrient to dissolve in the soil solution [23]. The oils are also known to block the openings found on the surface of the roots thereby inhibiting the gaseous exchange during root respiration and this causes the death of cells in the pericarp and the zone of elongation hence no root growth and development [24]. In one study, it was found that the growth of A. sativa was greatly affected by sunflower oil [11]. Furthermore, some researchers have reported that oils can be toxic as a result of secondary compounds formed due to biodegradation in the soil [1]. This in turn could lead to the observed death of plants before maturity in the study area, as they failed to extract necessary nutrients and available water from the soil solution.

The mean microbial biomass was greater in the upper slope field than the lower slope area. This showed that a lot of microorganisms were in the upper field than in the lower field. This could be due to the high viscosity of oil which increased its residence time on the soil surface forming a cover on top of soil surface. Some researchers have reported that sunflower oil polymerizes at the surface after 28 days and this results in the formation of a cap of increased shear strength and reduced permeability to water and oxygen [25]. The cover formed, could close the soil pore spaces leading to the death of soil microorganisms as a result suffocation [26]. It is reported that soil microorganisms play an important function in decomposition of organic matter to form humus and also help to enhance aeration and maintain soil structure through their ability to mix the soil as they move from one point to another [27]. Small number of microorganisms reduces the bio-degradation capacity of microorganisms thereby affecting the soil structure. As the bio-degradation process of oil is reduced, long period of time will be required for the oil wastes to degrade naturally. Therefore, the less the number of microorganisms in the lower slope field affected the soil structure hence negatively impacted on the crop production and development. However, studies have shown that the number of microorganisms increase in the oil after sometime and these decompose the oils leading to high acid values [11, 28]. The higher pH in the soils in this study could be a result of the same effects.

CONCLUSION

The results of this study have shown that the water quality is poor. The values of phosphorous, oil and grease, total dissolved solids and electrical conductivity were above the permissible limits in water in both seasons. Although, the values of dissolved oxygen, temperature, and pH were within the permissible limits, high levels of phosphorous, vegetable oil, TDS and E.C are a major cause of concern to communities leaving around the area. The high values of phosphorus, electrical conductivity and oil in the soil in lower field slope as compared to the upper slope suggested that over flow of the effluents in the lower field was possible. The smaller respiration value in the lower field indicated that microbial activity in this area was low and this could be the reason for the poor crop yields in that area compared to the other side of the stream.

REFERENCES

[1] Tamada IS, Montagolli RN, Paulo RM and Bidoia ED. Toxicological evaluation of vegetable oils and biodiesel in soil during the biodegradation process. Braz J Microbiology 2012; 43: 1576-1581. https://doi.org/10.1590/S1517-83822012000400042

[2] Schleicher T, Werkmeister R, Russ W and Pettroff RM. Microbiological stability of biodiesel-diesel-mixtures. Bio sci Bio technol 2009; 100: 724-730. https://doi.org/10.1016/j.biortech.2008.07.029

[3] Chiras DD. Environmental Science: A System approach to sustainable Development.5th edition. New York: Wadsworth Publishing Company1999.

[4] Deluca T. What effect does vegetable oil have in plants?. [Cited 2018 February 6]. Available from: https://www.hunker.com/12172266/what-effect-does-vegetable-oil-have-on-plants.

[5] Fitzpatric T. Vegetable oils hurt the environment. [Cited 2018 January 1]. Available from: https://source.wustl.edu/2003/07/vegetable-oil-spills-hurt-environment-too/.

[6] Li Z, Wincele DE and Wren BA. Biodegradation of vegetable oil spills. International oil spill 2001; 1: 315-321.

[7] Mckelvey R, Robertson I and Whitehead PE. Effect of non-petroleum oil spills on wintering birds near Vancouver. Marine Pollution Bulletin 1980; 11(6): 169-171. https://doi.org/10.1016/0025-326X(80)90146-0

[8] Selala MC, Botha AM, De Klerk AR, Myburg JG, Blettler MCM, et al. Effects of vegetable oil pollution on aquatic macro invertebrate assemblage in freshwater wetland and its use as a remediation tool. [Cited 2018 January 20]. Available https://doi.org.10.1007/s11270013-1650-x

[9] Annonymous. Impact of vegetable oild spills. [Cited 2018 January 23]. Available from: http://poopy.org/water-pollution/impact-of-vegetable-oil-spills/.

[10] Dumelin EE. The Environmental impact of palm oil and other vegetable oils. [Cited 2018 January 18]. Available from: https://www.palmoils.mpob.gov.my/publications/POD/pod51-erich.pdf.

[11] Gong Z, Li P, Wilke BM and Alef K. Effects of vegetable oil residue after soil extraction on physical-chemical properties of sandy soil and plant growth. Journal of Environmental Sciences 2008; 20(12): 1458-1462. https://doi.org/10.1016/S1001-0742(08)62549-8

[12] Phiri O, Mumba P, Kadewa WW and Moyo BHZ. Assessment of the impact of industrial effluents on water quality of receiving rivers in urban areas of Malawi. International Environmental Science Technology 2005: 2(3): 237-244. https://doi.org/10.1007/BF03325882

[13] Brady N and Weil R. The nature and properties of soils. 14th edition. Macmillan: New York 2008.

[14] AOAC. Association of official American Chemists. Official methods of Analysis, 17thedn. AOAC, MD, USA 2002.

[15] Charman PEV and Murphy BW. Soils: Their Properties and Management, 2nd edition, Oxford University Press 2000.

[16] Emongoret V, Kealotswe E, Koorapetse I, Sankwasa S and Keikanetswe S. Pollution Indicators in Gaborone Effluent. Journal of Application Science 2005: 5:147-150.

[17] WHO. World Health Organization: Guideline for Drinking Water Quality. 4th Ed, NLM Classification: WA 675, Geneva 2011.

[18] Metcalf E, George T. Wastewater engineering, Treatment and Reuse, 4th Ed, McGraw Hill, New York 2003.

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

[20] Kader MdA and Lindberg S. Cytosolic calcium and pH signaling in plants under salinity stress. Plant Signal Behaviour 2010; 5(3): 233-238. https://doi.org/10.4161/psb.5.3.10740

[21] Murray K, Du Preez M and Van Ginkel C. National Eutrophication Monitoring Programme Implementation Manual Draft. Water Research Commission, Pretoria 2000.

[22] Holdsworth R. New Health Consideration in Water Treatment, Avebury Technical, Aldershot. IRDC, Rural Water Supply in China. Journal Int Research 1991; 46(32): 1-11.

[23] Peirce JJ, Weiner RF and Vesillind PA. Environmental Pollution and Control. 4th edition. UK: Butterworth-Heinemann 1998.

[24] Bidlack JE and Jansky SH. Introduction to plant biology. 15th edition. McGraw-Hill: New York 2014.

[25] Mudge S, Goodchild I and Wheeler M. Vegetable oil spills on salt marshes. Chemistry and Ecology 1995; 10(1): 127-135. https://doi.org/10.1080/02757549508035336

[26] Annonymous. Does biofuel vegetable oil affect water pollution?. [Cited 2018 January 16]. Available from: http://homeguides.sfgate.com/biofuel-vegetable-oil-effect-water-pollution-79356.html/.

[27] Millar CE. Soil Fertility. 2nd edition. Biotech Books: Delhi 2007.

[28] Jianxin Z. The role of microorganisms in deterioration of vegetable oil and measures of controlling. In Jin, Liang Q, Liang Y, Tan X, Guan L, editors. Proceedings of the 7th International Working Conference on stored-product Protection, Beijing 14-19 October 1998; 1(14-19): 288-292.

Received on 28-06-2018 Accepted on 19-07-2018 Published on 10-08-2018

DOI: https://doi.org/10.12974/2311-8741.2018.06.1