International Journal of Research in Agricultural Sciences
Volume 2, Issue 1, ISSN(Online): 2348 – 3997)

The Influence of Agricultural Activities on the Water Quality of the River Sosiani in Uasin Gishu County, Kenya

George Ontumbi
Uasin Gishu High school P.O Box 380 Eldoret

Joy Obando
Kenyatta Univ ersity, Department of Geography P.O Box 43844 Nairobi

Christopher Ondieki
Kenyatta University, Department of Geography P.O Box 43844 Nairobi

Abstract: **The study assessed the influence of agricultural activities on the water quality of the River Sosiani in Uasin Gishu County, Kenya. This was carried out by identifying the agricultural activities within the River Sosiani catchment area and analyzing the spatial-temporal variation of physical-chemical variables of water quality along selected points in River Sosiani. The study adopted experimental research design where samples of river water were taken based on spatial-temporal variations for laboratory testing. The water samples were collected for two seasons, one dry and wet, from four selected sites identified by Landsat images reflecting agricultural activities in the vicinity and upstream. The samples were subjected to standard procedures for Total suspended solids, Turbidity, Electrical conductivity, temperature, pH, Nitrates and total phosphorous. The results showed that there were no significance difference in mean temperatures upstream and downstream (ANOVA; d.f =3, f =0.127 and p = 0.943) while the values of water pH ranged between 6.9 and 7.8 and electrical conductivity ranged between 36µS/CM and 142µS/CM. The study established that River Sosiani was stressed by nutrients originating from agricultural activities and therefore combined efforts of the County government and stakeholders were necessary to check further water degradation.**

Keywords: **Agriculture, River Sosiani, Spatial-Temporal, Water Samples and Water Quality**

1. Introduction

Water comprises over 70% of the Earth's surface, therefore undoubtedly the most precious natural resource that exists on the planet, without which life would be non-existent (Akali*et al.,* 2011). Additionally rivers play a major role as sources of water for both domestic and industrial use in many parts around the world (Masese*et al*., 2012). According to Tzimopoulo s*et al.,* (2005) the decrease of available water resources, the water quality degradation as well as the rapid increase of population combined with the growth of human activities; today impose the development of a science that concerns the Management of Water Resources

The world is on record to meet the Millennium Development Goals (Goal 7 Target 10 of the MDGs: Safe water and basic sanitation adopted by the UN General assembly in 2000 and revised after the world summit on sustainable development in Johannesburg (WHO/UNICEF 2004) . The summit in Johannesburg laid emphasis on access to safe water for drinking. An estimated 1.2 billion people drink unclean water which is the source of water related diseases that kill between five-ten million people mostly children around the world. The world is facing a global water quality crisis, and expanding farming activities are putting pressure on water resources and increasing the unregulated or illegal discharge of contaminants into rivers thereby affecting negatively the ecosystem. Whether we approve or not rivers are receptacles for large amounts of waste produced by farming (Shaw 2004).

Erosion is a natural process that provides sediments and organic matter to water systems and further could lead to loss of soil fertility in crop land areas and deterioration in water quality through sedimentation (UNEP 2010 and Ayivor & Gordon 2012). The nutrient discharge through inappropriate use of agrochemicals and bush burning may result in eutrophication and high nutrient loads. In many regions, human activities have altered natural erosion rates and greatly altered the volume, rate, and timing of sediment entering streams and lakes, affecting physical and chemical processes and species' adaptations to pre-existing sediment regimes.

Large losses of nutrients from agricultural land may be caused by intensive use of fertilizers where several investigations have shown that concentrations of nutrients in river water are strongly correlated to the percentage of agricultural land in the study basins (Stålnacke*et al.,* 2003). Unfortunately, with increasing population, adequate food supplies can only be maintained by the use of fertilizers which have resulted to loss of biodiversity and algal blooms. Once it rains the exposed soil sediments are carried to the river resulting to increased amounts of suspended solids (SS) and dissolved solids (DS).

In East Africa, land use changes caused by rapid urbanization and clearance of forests to create room for agriculture have emerged as major stressors of streams and rivers. Deforestation and cultivation have been found to cause an increase in water temperature, conductivity, total suspended and dissolved solids and turbidity (Kibichii *et al.,* 2007 and Kasangaki*et al*., 2008). Raburu*et al*., (2009) eludes that near stream human activities like sand mining, bathing, laundry and row crop agriculture have been reported to cause the greatest influence on stream habitat and biotic characteristics. For water scarce countries, including Kenya (WRI, 2007) the water catchment areas should be managed properly so as to retain their capacity to supply good quality water all year round. In Kenya, land use changes on various catchments and water towers have been increasingly characterized by human settlement, deforestation, wetland reclamation and unsustainable agricultural activities (UNEP, 2006 & Aura *et al.,* 2010).

2. Research Design and Methodology

2.1 Study Area

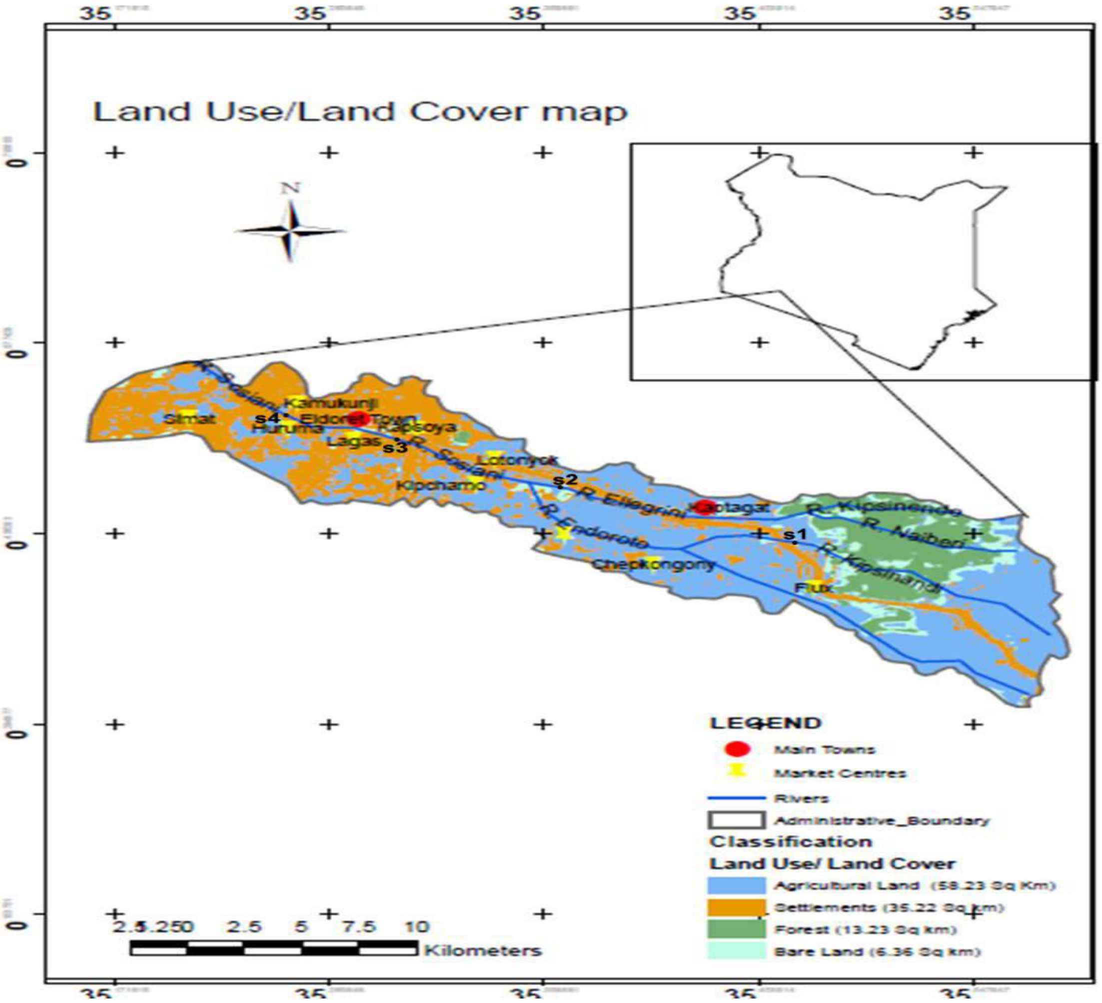

Fig.1. TheWater Sampling Sites Denoted S1, S2, S3 and S4 are Flax, Plateau, Nairobi Road and Kipkaren Bridge.

2.2 Research Design

This study adopted experimental research design where the natural environment is exposed to an intervention in its own environment and the researcher observes a phenomenon and attempts to establish what caused it (Kumar, 2011). The sampling sites were selected to ensure that the samples reflected the effects of land use types in the vicinity and upstream of the sampling point. Once the water samples were collected they were subjected to standard procedures for testing of the physical chemical qualities of water quality.

2.3 Sampling procedure

According to (Kumar, 2011) the researcher knows that the environment is being exposed or has been exposed to an intervention and wishes to study its impact on the environment. Therefore based on the Landuse activities identified from the land sat images, the sites identified for water sampling included; Flax Bridge (S1); Plateau Bridge (S2); Nairobi Road Bridge (S3) and the Kipkaren Bridge (S4) denoted in Figure 1.

2.3 Data collection

Water samples were collected from the river during the dry and wet season and subjected to laboratory testing to establish the status of their chemical-physical qualities. The Hydro meteorological Data on climate and the gauge height for the Nondoroto and Ellegrine RGS was obtained from the Kapsoya meteorological station and the Water Resources Management Authority (WRMA) regional offices in Eldoret. The agricultural activities in the Sosiani River catchment were identified by observation and from Land sat images on the land use/land cover. The land use/cover was analysed in a GIS environment and ground truthing was undertaken to confirm the land use/cover.

The water samples were collected from four sites a long river Sosiani during both the dry and wet seasons where the distance from one sampling station to the next one was approximately 6 kilometers for a fair comparison of the parameters that were analyzed. Before water sampling the water sample bottles were cleaned by soaking in a detergent for 24 hours, followed by rinsing with tap water until they were free of the detergent and rinsed with distilled water. The water samples were collected from the deepest and mid-section of the river channel using

Sterilized sample bottles in triplicate between 10 a.m. and mid-day on the sampling dates from the four sites.

2.4 Pilot case study

To ensure the reliability of the research instruments, piloting was done in the River Sosiani one month prior to the date of the research. The water samples were later tested in the laboratory and their results were compared to the results of the routine tests carried by the Water Resources Management Authority (WRMA). The results of the water samples achieved had similarity with the routine WRMA water sample tests.

2.5 Data Analysis

Data was coded and inferences made (Kombo and Tromp, 2006), collected data on water samples was analyzed using inferential statistical techniques. Data on water quality parameters were analyzed using a Statistical Package for Social Sciences (SPSS version 20) where the seasonal and site variations for selected physical water quality parameters for the wet and dry seasons and amongst the four sampling sites were performed using ANOVA. A one way ANOVA for variables were specifically used to compute the statistical significance of the parameters concentration during the wet and dry seasons and upstream site at Flax and downstream site at Kipkaren along the River Sosiani. In comparing the variance ANOVA was used for Flax and Kipkaren sites due to the gradual changes in Land use from upstream to downstream. In all the analysis, 95% level of significance was used as the critical point ($P < 0.05$).

Variations in sampling sites for selected physical-chemical water quality parameters were performed using t-test for paired variables were specifically used to compute the statistical significance of the parameters concentration in each sampling station along the River Sosiani. In all the analysis, 95% level of significance was used as the critical point ($P < 0.05$).

3 Results and Discussion

3.1 Rainfall data

The rainfall regime in the Sosiani sub catchment is bimodal with annual average of 900 mm which falls between the months of April and May. Figure 2 shows the total monthly rainfall for a station in the study area. There is a dry spell in June followed by increasing rainfall in July and August and tails off in September and October. The wet months are April, May, June, July and August while the dry months are October, November, December, January, February and March. The average daily temperatures are 24° C with average night temperatures being 10° C. Being in the tropics; most days are sunny with a mean sunshine of 7.7 hours.

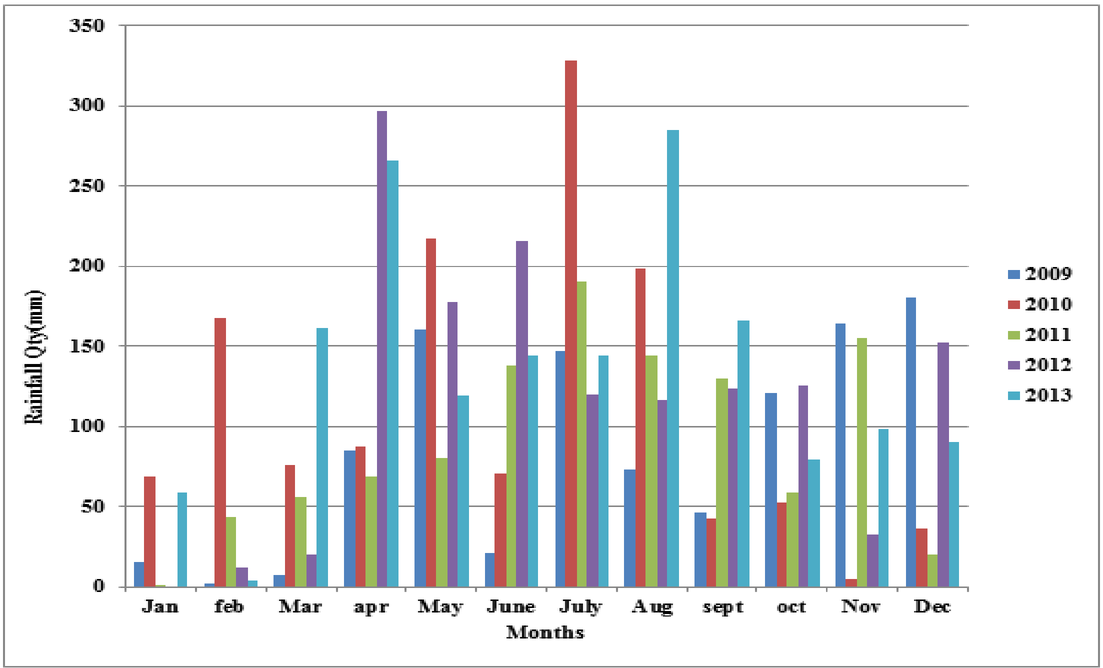

Fig.2.Total Monthly Rainfall (Mm) Data for EldoretMeteorological Station (2009-2013)

3.2 Agricultural activities

Through ground truthing survey and observation the main agricultural activities identified included, livestock and crop cultivation mainly wheat and maize farms around plateau and Naiberi areas, green house farming and tree nurseries.

From the Landsat images of 2008 it were deduced that the land under agriculture occupied 43217.7 hectares. The increase in size of the bare ground area was an indication of forest land degradation and replacement with bare soil that is prone to soil erosion. In the upper and middle zones of the catchment there were livestock keeping, maize and wheat farms.

International Journal of Research in Agricultural Sciences
Volume 2, Issue 1, ISSN(Online): 2348 – 3997)

Plate 1.Cattle Watering Point in River Sosiani

Plate 2.Maize Farm in the River Sosiani Catchment

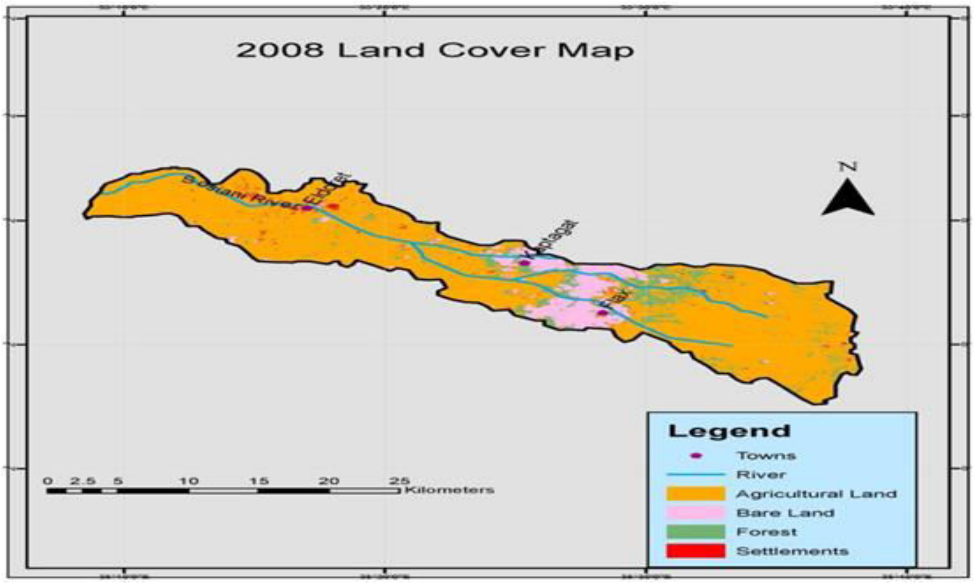

Fig.3.Landuse/Land Cover Map (2008) in the River SosianiCatchment

In the River Sosiani there was crop and livestock rearing**.** These findings are supported by Aura *et al.*, (2010) in Rivers Kipkaren and Sosiani, River Nzoia basin who asserted that in Kenya, land use changes on various catchments and water towers have been increasingly characterized by human settlement, deforestation, wetland reclamation and unsustainable agricultural activities. Most of the River Nzoia watershed has been deforested and under crop production hence 60% of the land is arable and mostly under cultivation for maize and sunflower (GoK 2002).

3.3 Physical-chemical parameters during the dry season

Table 1. Physical-Chemical Parameters During the Dry Season

	Sampling Site	Mean	Std. Error	Minimum	Maximum
TEMPERATURE. D. Season	**Flax**	20.63	0.96	16.00	25.00
	Plateau	21.00	0.99	16.00	26.00
	Nairobi Road	21.18	0.78	17.00	25.00
	Kipkaren Bridge	21.38	0.81	16.00	25.00
TURBIDITY. D. Season	**Flax**	12.12	2.17	3.20	22.64
	Plateau	17.00	1.51	8.00	23.00
	Nairobi Road	8.85	1.25	2.98	13.60
	Kipkaren Bridge	19.45	1.85	7.00	26.00
ELECRICAL CONDUCTIVITY.D. Season	**Flax**	76.08	9.80	44.00	142.00

	Plateau	77.50	8.27	47.00	138.00
	Nairobi Road	66.67	7.91	36.00	112.00
	Kipkaren Bridge	73.75	6.46	48.00	116.00
pH. D. Season	Flax	7.15	0.05	7.00	7.40
	Plateau	7.10	0.04	6.90	7.20
	Nairobi Road	7.13	0.33	7.00	7.30
	Kipkaren Bridge	7.23	0.10	7.00	7.80

The value of water temperature during the dry season ranged between a minimum of 16 ºC at Flax Bridge and a maximum of 26 ºC at the Plateau site with a mean value of 21.0 ºC ± 0.99. The Nairobi road and the Kipkaren Bridge sampling points recorded average temperatures of 21.18 ºC ± 0.78 and 21.38 ºC ± 0.81 respectively. There was no significance difference in mean temperature between Flax and Kipkaren (ANOVA d.f =3, f =0.127 and $p > 0.05$). Further analysis by Post Hoc indicated no significance difference in temperature between Flax and Kipkaren (Tukeys', HSD test $p > 0.05$). The results showed little difference in mean temperature between upstream at Flax and downstream at the Kipkaren Bridge.

The mean values of water pH during the dry season as shown in Table 1 ranged between 6.9 at the Plateau sampling point and 7.8 at the Kipkaren sampling point with a mean value of 7.23 ± 0.10. There was no significance difference in pH between Flax and Kipkaren (ANOVA d.f =3, f = 0.772 and $p > 0.05$). The highest value of pH of 7.8 was recorded at the Kipkaren site while the lowest pH was 6.9 recorded at the Plateau sampling site.

Value of electrical conductivity during the dry season ranged between 36 µS/CM at the Nairobi road sampling point with a mean of 66.67 µS/CM ± 7.91 and a maximum of 142 µS/CM at the Flax sampling point with a mean value of 76.08 µS/CM ± 4.011. There was no significant difference in conductivity observed between the sampling sites (ANOVA d.f =3, f =0.345 and $p > 0.05$). Finally the values of turbidity during the dry season ranged between 2.98 NTU at the Nairobi Road sampling point with a mean of 8.85 NTU ± 4.34 and a maximum of 26 NTU at the Kipkaren sampling point with a mean value of 19.45 NTU ± 1.85. The Flax and the plateau sampling points recorded the mean values of 12.12 NTU and 17.0 NTU respectively during the dry season as shown in appendix V. The mean values of turbidity differed significantly along the four sampling points (ANOVA d.f =3, f =7.6 and $p < 0.05$). Further analysis by Post hoc indicated a significance difference in turbidity between the sampling sites of Flax, Plateau, Nairobi Road and Kipkaren (Tukeys', HSD test $p < 0.05$). The results on turbidity indicated that the varied human activities in the River Sosiani catchment had an influence on the water turbidity of River Sosiani. The clearing of the forests and the preparation of land for maize cultivation resulted to increased surface runoff resulting to the high values of turbidity during the season.

3.4 Physical-chemical variables during the wet season

Table 2: Physical-Chemical Variables Duringthe Wet Season

	Sampling Site	Mean	Std. Error	Minimum	Maximum
TEMPERATURE. W. Season	Flax	19.65	0.91	15.00	25.00
	Plateau	18.28	0.92	13.10	23.00
	Nairobi Road	18.24	0.59	15.20	21.30
	Kipkaren Bridge	18.72	0.83	14.00	24.00
TURBIDITY. W. Season	Flax	21.00	5.87	4.00	58.00
	Plateau	65.75	12.79	16.00	142.00
	Nairobi Road	25.25	4.85	7.00	50.00
	Kipkaren Bridge	52.33	11.06	8.00	116.00
Electrical Cond. W. Season	Flax	99.00	13.57	44.00	176.00
	Plateau	94.50	7.52	60.00	132.00
	Nairobi Road	130.50	11.06	94.00	198.00
	Kipkaren Bridge	116.58	13.51	65.00	192.00
pH. W. Season	Flax	7.06	0.06	6.80	7.30
	Plateau	7.20	0.04	7.10	7.40
	Nairobi Road	6.98	0.09	6.60	7.30
	Kipkaren Bridge	7.08	0.04	6.90	7.20

The values of water temperature wet season (Table 2) ranged between 13.10 ºC at Plateau sampling point with a mean of 18.28 ºC ± 0.92 and 25.00 ºC at the Flax sampling point with a mean value of 18.7 ºC ± 0.91.The Kipkarenand Nairobi Road sampling points recorded the maximum temperatures of 24.00 ºC and 21.30 ºC

respectively. There was no significance difference in mean temperature
between Flax and Kipkaren (ANOVA d.f =3, f =0.637 = and p = 0.595).

Values for electrical conductivity observed during the wet season (Table 2) ranged between 44 µS/CM with a mean of 99.00 µS/CM ±13.57 and 198 µS/CM with a mean value of 130.50 µS/CM ± 11.06 for the Flax and Nairobi Road sampling points respectively. There was no significant difference in electrical conductivity observed between upstream at Flax and downstream at Kipkaren(ANOVA d.f =3, f =2.015 and p = 0.126).

The mean values of water pH during the wet season ranged between a minimum of 6.6 at Nairobi Road and 7.4 at the Plateau sampling point with a mean value of 7.20 ± 0.04. The Flax and Kipkaren sampling points recorded the averages of 7.06 ± 0.06 and 7.08 ± 0.04 respectively. There was no significance difference in pH between Flax and Kipkaren (ANOVA d.f =3, f = 2.468 and p = 0.075).

Finally the values of turbidity during the wet season ranged between 4 NTU at the Flax sampling point with a mean of 21.00 NTU ± 5.87 and 142 NTU at the Plateau sampling point with a mean value of 65.75 NTU ± 512.79 as shown in table 5. The Nairobi Road and Kipkaren Bridge recorded the averages of 52.33 NTU ± 11.06 and 25.25 NTU ± 4.85 respectively. The mean values of turbidity differed significantly amongst the four sampling sites (ANOVA d.f =3, f = 5.385 and p = 0.003).

The effects of agricultural activities along the River Sosiani catchment were manifested in the changes in the water quality parameters from upstream at Flax to downstream at Kipkaren Bridge**.** The high levels of temperature, total phosphates, nitrates, pH, turbidity, electrical conductivity and total suspended solids increased downstream. These results were confirmed by the study of Masese*et al.,* (2009) a study along Moiben River who found high conductivities at disturbed sites and attributed it to presence of litter from the riparian zone and agro chemicals from agricultural farms.

3.5 Total phosphorous and nitrates in River Sosiani during the dry and wet seasons

The levels of total phosphates during the dry season ranged between a minimum of 0.030 mg/l and a maximum of 0.760 mg/l with a mean value of 0.229 ± 0.036. On the other hand the levels of total phosphates during the wet season ranged between a minimum of 0.320 mg/l and a maximum of 1.24 mg/l with a mean value of 0.660 ± 0.040. Paired sample test analysis during the wet and dry seasons indicated that there was a significant variation between the seasons (t =-11.2, d.f =47 and p< 0.05) with a correlation of 0.493. There was a significant variation in the levels of total phosphates during the wet and dry seasons this would have been attributed to leaching and surface runoff.

The levels of Nitrates during the dry and wet seasons are shown in table 7. The values of nitrates ranged between a minimum of 0.010 mg/l and a maximum of 0.180 mg/l with a mean value of 0.035 ± 0.007. During the wet season the values of nitrates ranged between 0.750 mg/l and 1.160 mg/l with a mean value of 0.968 mg/l ± 0.016. Paired sample test analysis indicated a significant variation between Flax and Kipkaren (t = -66.88, d.f =47 and p< 0.05) with a correlation of 0.451. The Pearson correlation of nitrates during the dry season was significant at 0.01 level (2 tailed).

From this study it was observed that once the rains started the surface runoff swept the cleared forested land which resulted to high levels of the water quality parameters. Similar observations are supported by Kibichi*et al.,* whoasserted that animal overuse on the riparian areas were found to increase ammonia and nitrite as a consequence of increased run-off of animal wastes into streams of river Njoro. Further Twesigye*et al*., (2011) and Coulter *et al*., (2004) concluded that the physical and chemical analysis of water quality in River Nzoia Basin revealed high levels of phosphates and nitrates along the agricultural zones.

Table 3.Total Phosphorous and Nitrates

	N	Min	Max	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
TPW	48	0.320	1.240	0.660	0.040	0.276
ND	48	0.001	0.180	0.035	0.007	0.047
NW	48	0.750	1.160	0.968	0.016	0.108
TPD	48	0.030	0.760	0.229	0.036	0.250

Where **TPW** is Total phosphorous wet season, **TPD** is Total phosphorous dry season, **ND** is Nitrates during dry season and **NW** is Nitrates wet season

4.CONCLUSIONS

During the period of study the physical chemical variables of water quality differed between upstream at Flax and downstream at the Kipkaren Bridge. Temperature exhibited spatial variation with the upstream site (Flax area) recording low temperatures as compare to downstream points of Nairobi Road and Kipkaren. The low temperatures at Flax were attributed to the density of vegetation cover and of riparian vegetation that determined the shading effect on the Site. The flax area had the lowest pH values than all the other sites; this was expected of it as the water at that particular site was noted to be very clear with minimal anthropogenic activities. This trend was also noted with TDS, turbidity and conductivity. The study was able to show that agricultural activities have interference on the water quality of River Sosiani.

The nutrient levels varied significantly among the water sampling stations. Station 1 upstream at Flax recorded the lowest concentrations of total phosphorus while the Kipkaren bridge site recorded the highest levels of both nitrates and total phosphorous. Total nitrogen also displayed the same trend because the Flax area was experiencing low crop cultivation. Downstream after Flax the levels of nitrates and phosphates showed an increasing trend.

5. Recommendations

The study recommends that all the land use and development activities in the water catchments should put into consideration the ecological integrity and environmental consequences therefore need for an Environmental Impact Assessment should for all new developments including settlement, farming, industries, urban development and waste disposal sites along River Sosiani.

References

[1] Akali, N. M., Nyongesa, N. D., Neyole, E.M & Miima, J. B (2011): Effluent Discharge by Mumias Sugar Company in Kenya: An Empirical Investigation of the Pollution of River Nzoia: Sacha Journal of Environmental Studies, Volume 1 pp. 1-30.

[2] Aura, M.C., Raburu, P.C and Hermann, J. (2011). Macro invertebrates' community structure in rivers Kipkaren and Sosiani, River Nzoia basin. Journal of Ecology and the Natural Environment Vol. 3(2), pp. 39-46.

[3] Ayivor, J. S. & Gordon, C. (2012). Impact of Land Use on River Systems in Ghana. *West* African Journal of Applied Ecology, Vol. 20 (3), 2012

[4] Coulter, C. B., Kolka, R. K., & Thompson, J. A. (2004). Water quality in agricultural, urban and mixed land use watersheds. *Journal of the American Water Resources Association, 40*(6), 1593-1601.

[5] GoK (2002). Trans Nzoia district development plan 2002-2008, Ministry of Finance and Planning, Nairobi.

[6] Kasangaki A, Chapman, L.J, Balirwa J (2008). Land use and the ecology of benthic macro invertebrate assemblages of high-altitude rainforest streams in Uganda. Freshwater. Journal of Ecology. 53: 681-697.

[7] Kibichii, S, Shivoga, W.A, Muchiri, M and Miller, S.N (2007). Macro invertebrate assemblages along a land-use gradient in the upper River Njoro watershed of Lake Nakuru drainage basin, Kenya. Lakes and Reservoirs: Research and Management.

[8] Kombo, D.K. & Tromp, D.L.A (2006). Proposal and Thesis Writing: An Introduction, Nairobi: Pauline Publications Africa, pp 10-45.

[9] Kumar, R (2011). Research Methodology; a step by step guide for beginners.SAGE publications Ltd, London.

[10] Masese, F. O, Muchiri, M and Raburu, P.O (2009). Macro invertebrate assemblages as biological indicators of water quality in the Moiben River, Kenya. African Journal of Aquatic Science. 34:15-26.

[11] Raburu, P.O, Masese F.O, Mulanda C.A (2009). Macro invertebrate Index of Biotic Integrity (M-IBI) for monitoring rivers in the upper catchment of Lake Victoria Basin, Kenya. Aquatic Ecosystem Health Management pgs 1-9.

[12] Shaw, E.(2004) Hydrology in practice. Stanley Thornes (publishers) ltd.

[13] Stålnacke, P, Grimvall, A, Libiseller, C, Laznik C. and Kokorite, I. (2003). Trends in nutrient concentrations in Latvian rivers and response to the dramatic change in agriculture. Journal of Hydrology, 283: 184-2005.

[14] Twesigye, C.K, Onywere, S.M, Getenga, Z.M, Mwakalila, S.S and Nakiranda, J.K (2011). The Impact of Land Use Activities on Vegetation Cover and Water Quality in the Lake Victoria Watershed. The Open Environmental Engineering Journal, Vol. 4 (pgs 66-77).

[15] Tzimopoulos, C, Zeibeki, A, Ginidi, P&Evangelides, C. (2005). Water resources management in the watershed of volvi lake Global NEST Journal, Vol 7, No 3, pp 379-385.

[16] UNEP (2006) Lake Victoria basin environmental outlook: environment and development. UNEP, NairobiWHO/UNICEF (2004).Meeting the MDG drinking water and sanitation target. A mid term Assessment of progress, Geneva.

[17] WRI (2007) World Resources Institute, Department of Resource Surveys and remote Sensing, Ministry of Environment and Natural resources, Kenya, Central Bureau of Statistics, Ministry of Planning and Development, Kenya; and International Livestock Research Institute: Nature's Benefits in Kenya: An Atlas of Ecosystems and Human Well-Being, World Resources Institute, Washington, DC, and Nairobi.

Author's Profile

Mr George Morara Ontumbi Moi university B.Ed Geography (Major) and Economics Currently Undertaking M.sc in Hydrology and water Resources (Kenyatta University).Current position: Senior Teacher Uasin Gishu High School, Eldoret, Kenya.Contact: 0721314191
email: ontumbigeorge@yahoo.com

Professor Joy Apiyo Obando Associate professor Department of Geography, Kenyatta University, Kenya.

Dr. Christopher Misati Ondieki Senior Lecturer Department of Geography, Kenyatta University, Kenya.