Quest Journals
Journal of Research in Environmental and Earth Science
Volume 3~ Issue 5 (2017) pp: 75-82
ISSN(Online) : 2348-2532
www.questjournals.org

Research Paper

Impacts of Farm Management Practices on Levels of Nitrates And Phosphates in water Along the Kithinu And Mutonga Rivers Catchment Areas, Kenya.

Wambugu A.W[1], Dr. Karanja R.[2], Dr. Wakibia J.[3]

Received 14 October, 2017; **A**ccepted 28 October, 2017

ABSTRACT: *This study aimed at assessing the impacts of farm management practices on levels of nitrates and phosphates in water along the river Kithinu and Mutonga catchments areas, where small holder irrigation projects exists. Laboratory assessments of water quality at points upstream, within and downstream of the irrigation projects were done. Information on farm management practices was also obtained by use of questionnaires, interviews, focus discussions and observation from the farmers. From the study, farmers in the irrigation projects use a wide range of agrochemicals in crop production. They also widely use both organic and inorganic soil amendments in their farms. Soil conservation measures and protection of the riparian areas is also not embraced by all. Nitrate values detected in some sampling sites were beyond the recommended WHO and KEBS standards for drinking water. It was thus concluded that the lack of good farm management practices in the study area was contributing to the presence of nitrates and phosphates in water, which is impacting negatively on the ecosystem health of the area.The study further recommends more education to be done to farmers on good farm management practices and constant water quality monitoring for sustainable food production.*

Keywords*: Agrochemicals, irrigation, Plant nutrients, residues, water quality.*

I. INTRODUCTION

Kenya in its achievement of the Millennium Development Goals to promote agriculture productivity as well as its vision 2030 has opened up irrigation areas where water is available [1, 2, 3]. The increasing world population and economic growth are driving an increasing demand for agricultural products. This has led to new lands being opened up for agricultural use as well as large use of agrochemicals and fertilizers to increase productivity [4, 5]. During the year 2013-2014, a total of 58,386.5 acres of new land was put under irrigation under the Galana/Kulalu food security project, expanded national irrigation projects and smallholder irrigation programmes [5]. This has been done with the aim of increasing food productivity in Kenya.

The growing of crops using irrigation in South Imenti sub county of Meru County and Maara sub county of Tharaka County in Kenya has increased in the recent years of 2010-2011. Ciamchogia, Maraka Mgambo, Gikuruni and Maara irrigation projects have increased their production capacities while others have emerged within the 2010- 2011 [6]. River Kithinu and river Mutonga are reliable sources of domestic as well as irrigation water in these counties. Agricultural activities if not well managed may have a negative impact on soil, surface water and ground water quality hence the need to constantly monitor the water quality as a result of these increased agricultural activities. Agriculture has been enumerated as a major cause of water pollution [7]. This pollution tends to arise over a wide geographical area and is dependent on what happens on the surface of the land. Agricultural wastes include the pesticides that are sprayed on crops, as well as sediment, fertilizers and plant and animal debris that are carried into waterways during periods of rainfall or as runoff and during the irrigation of farmland [8,9]. Studies conducted, have shown irrigation activities to have detrimental effects on water quality [10, 11, 12]. This would render the water body unsafe for domestic purposes. Plant nutrients (nitrates and phosphates) enter fresh and marine systems and lead to or intensify eutrophication of these systems, which get interferences with water uses and later decay to produce bad odours and add to the Biological Oxygen Demand (BOD) of the water [7]. Consumption of water with high levels of nitrates can cause methemoglobinemia or “blue baby” disease. Although nitrate levels that affect infants do not pose a threat to adults, they do indicate the presence of more serious residential or agricultural contaminants such as bacteria or pesticides [13].

The information generated in this study will be used in guiding farmers in small holder irrigation projects on the need for good farm management practices and hence sustainable agriculture production.

II. MATERIALS AND METHODS

2.1. Study Design, Area And Population.

A descriptive survey was conducted in five purposefully selected irrigation projects located along the Kithinu and Mutonga rivers catchment areas. It involved collection of information through the use of questionnaires, interviews, observation and focus group discussions. The population involved were farmers in the Ciamchogia, Mitunguu Farmers, Ngu'rwe Gakirwe, Gikuruni and Maara- Kamuramba irrigation projects. Fisher's random number table was used to select the farm households to be interviewed [14].

The study also involved laboratory analysis of water for the presence of nitrates and phosphates. Observation for pollution indicators in the water was also done.

2.2. Water And Sediment Samples

Random selection of points for water and sediment sample collection was done. A total of 10 sampling stations were established. Four of these points (K1, K2, M1 and M2) are located before, four points (K3, K4a, K4b, and M3) are located within and the other two points (K5, and M5) are located after the various irrigation projects as shown in the map (Fig. 1). Grab water samples were collected 50cm below the water surface [15]. Water samples were collected in two seasons; dry season and rainy season. The samples for the dry season were collected in the months of August and September 2016, while samples for the rainy season were collected in the months of April and May 2016.

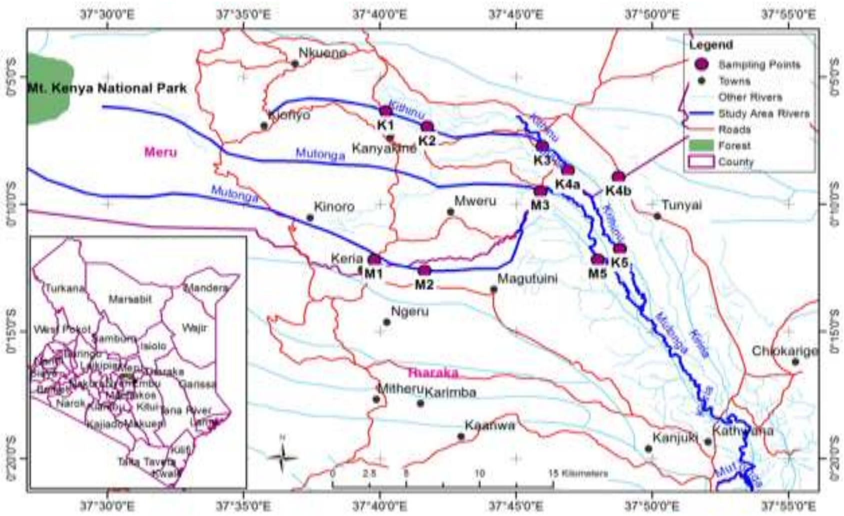

Figure 1; A map showing River Mutonga and River Kithino catchments and location of the sampling sites.

2.3. Determination Of Nitrates In Water Samples.

Water samples stored at 4^0C were analysed for nitrates using the Ultraviolet (UV) Spectrophotometric screening method [15]. 1ml of HCL solution was added to 50ml of water sample and thoroughly mixed. The absorbance or transmittance was read on the spectrophotometer against redistilled water at zero absorbance. Standard curves were prepared using standard nitrate stocks. A wavelength of 220nm was used to obtain NO_3^- reading, while a wavelength of 275nm was used to determine interferences.

2.4. Determination Of Phosphates In Water Samples.

Water samples stored at 4^0C were analysed for phosphates using the Ascobic Acid Method [15]. 0.005ml (1drop) of phenolphthalein indicator was added to 50ml water sample. When a red colour developed, 5N H_2SO_4 solution was added drop wise until the colour disappeared. 8ml of combined reagents for phosphate tests were added and mixed thoroughly. After at least 10 minutes but not more than 30 minutes, the absorbance was read on the spectrophotometer at a wavelength of 880nm, against a reagent blank as a reference solution.

2.5. Data Processing And Analysis.

Data was entered in Excel spreadsheets and cleaned up. Information gathered from the interviews was analysed using Microsoft Excel and Statistical Packages for Social Sciences (SPSS) (version 16.0). Mean concentrations for nitrates and phosphates were calculated using SPSS and compared with the World Health Organisation (WHO) standard for domestic water [16] and Kenya Bureau of Standards (KEBS) for domestic water supplies to establish if they lie within the permissible levels. Multiple comparisons with one way ANOVA were used to test significance differences of physico-chemical parameters and plant residues among the different sampling sites and across seasons.

III. RESULTS AND DISCUSSION

3.1. Farm Management Practices along River Mutonga and River Kithinu catchments.

Some of the farm management practices investigated during the study was the various agrochemicals used during farming, use of organic and inorganic fertilizers, soil conservation measures in use, personal protection equipment (PPEs) used during application of the agrochemicals and their waste containers disposal methods, level of knowledge on use of PPEs and protection of the riparian areas.

3.1.1. Agrochemicals and soil amendments used in the River Mutonga and River Kithinu catchments.

The study indicates that all classes of pesticides are used in the area. These include organochlorines, organophosphorus, inorganics, pyrethroids and carbamates. These agrochemicals used ranged from highly hazardous to slightly hazardous as classified by World Health Organisation [17]. Farmers use both inorganic fertilizers and organic manures from domestic animals during farming.

3.1.2. Soil conservation measures in the study area

Fig. 2 shows the various soil conservation measures used in River Kithinu and Mutonga catchment areas.

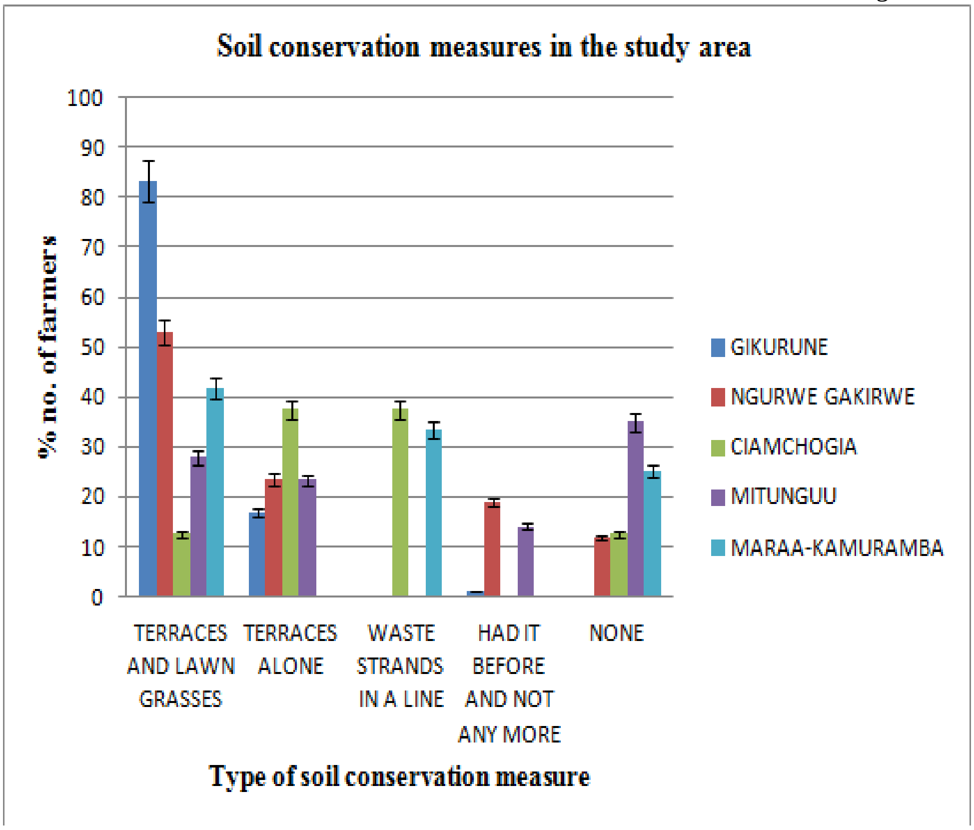

Figure 2: Bar graph showing soil conservation measures utilised in the study area

An overall population of 40.2% farmers in the irrigation projects have embraced good soil conservation measures using both the terraces and lawn grasses. Gikurune irrigation project registered the highest percentage of 83% of farmers using both the terraces and lawn grasses to conserve soil. This may have been attributed to the steep/sloppy terrain in the area. However in each of the irrigation project except Gikurune, there were some farmers with no soil conservation measure in their farms. An overall population of 22.8% farmers had no soil conservation measures on their farm.

3.1.3. Level of knowledge on use of Personal Protective equipments (PPEs) in the study area.

Fig. 3. Shows level of knowledge on use of PPEs used in the study area.

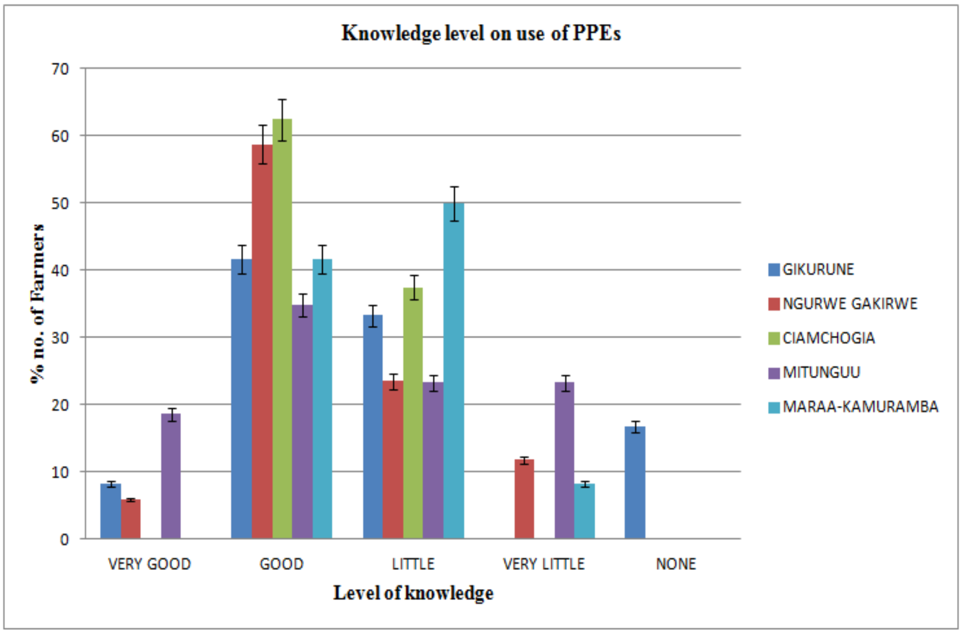

Figure 3: A bar graph indicating level of Knowledge on use of PPEs

Very good level of knowledge on the use of PPEs included farmers who have undergone training on use of PPEs and even awarded certificates. Good level of knowledge were farmers who had undergone public trainings on use of PPEs without necessarily having a certificate, little level of knowledge were farmers who had not undergone training but learnt from fellow farmers on use of PPEs, very little had just heard and never took the advise while none were farmers with no idea on the need to use the PPEs. A total population of 10.9% had very good knowledge and 48.9% had good level of knowledge, 2.2% farmers had no knowledge on the need to use PPEs.

3.1.4. Use of Personal Protective Equipments (PPEs)

Fig. 4. Shows the various types of PPEs used in the study area while applying pesticides.

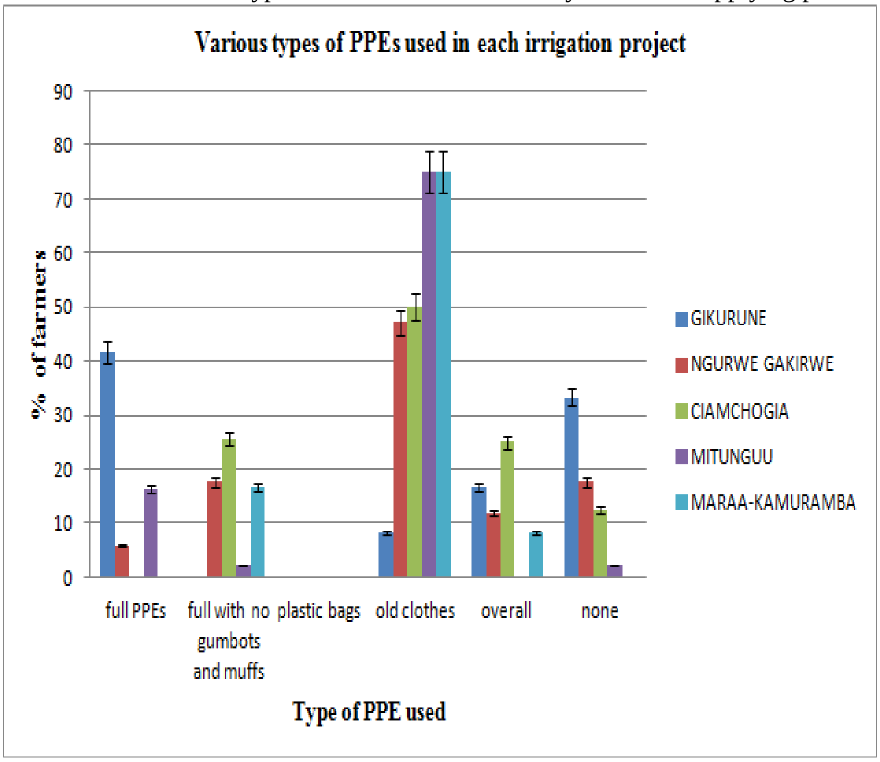

Figure 4: A bar graph showing the PPEs used while applying agrochemical along the Mutonga and Kithinu river catchments.

An overall population of 60.9% of farmers use old clothes as PPEs while applying agrochemicals and an overall population of 9.8% do not use any form of protection.

3.1.5. Protection of the riparian area.

An overall population of 44.1% had left a distance of 0-10 meters before start of their irrigation field. The Water Resources Authority a body enacted by the water Act 2012 to manage and conserve water catchment areas indicated that the distance is dependent on the width of the river [18].

3.1.6. Disposal of agrochemical waste containers.

Fig. 5. Shows the various methods used by farmers in disposing the agrochemical waste containers or sachets in the various irrigation projects.

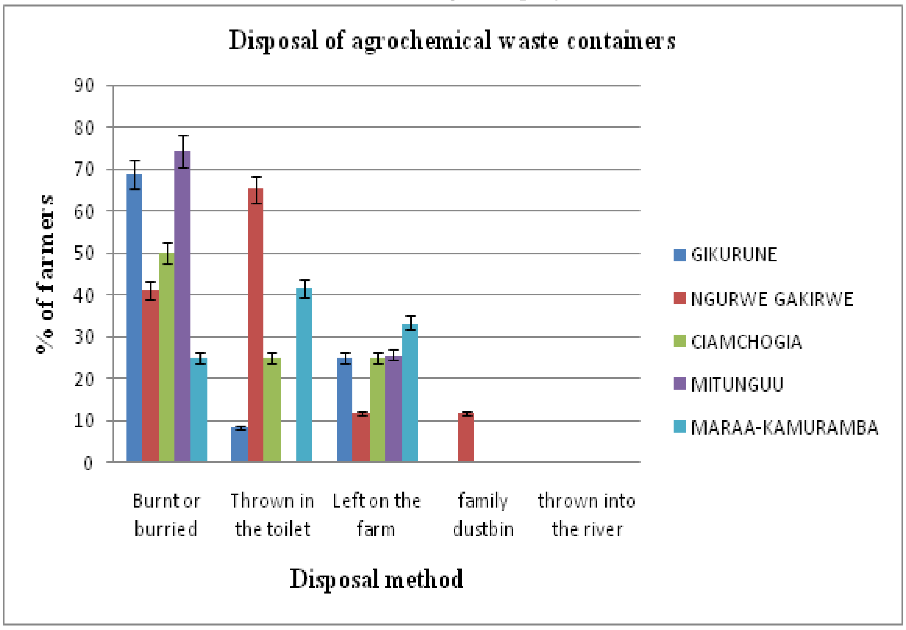

Figure 5: A bar graph showing waste container disposal method used by farmers along the Kithinu and Mutonga river catchment areas.

A population of 58.7% had either burnt or buried their agrochemical containers waste while no farmer had thrown his waste container into the rivers. This reduces incidences of direct contamination of the water body.

3.2. Water quality analysis.

Laboratory analysis for physiochemical analysis and presence of plant nutrients, particularly nitrates and phosphates was done.

3.2.1. Physiochemical data

TABLE 1 shows the levels of pH, electrical conductivity (EC) and total dissolved solids (TDS) for the wet season and dry season for the various sampling points selected along river Mutonga and river Kithinu in the study area.

Table 1: Physiochemical parameters of the sampling sites during the wet season (April-May 2016) and during the dry season (August-September 2016).

SAMPLING SITE	**pH**		**TDS (ppm)**		**eC (□S/cm)**	
	wet	**dry**	**wet**	**dry**	**wet**	**dry**
Mutonga 1 (M1)	7.17	6.97	49.6	68.24	99.1	136.7
Mutonga 2 (M2)	7.18	6.97	49.8	68.24	99.4	136.8
Mutonga 3 (M3)	7.42	7.64	55.5	84.19	102.4	167.89
Mutonga 5 (M5)	7.45	7.22	64.5	97.26	132.5	201.86
Kithinu 1 (K1)	7.63	7.84	34.6	54.19	69.2	110.08
Kithinu 2 (K2)	7.63	7.84	34.7	54.21	69.2	110.08
Kithinu 3 (K3)	7.55	7.33	69.9	78.36	142.3	156.94
Kithinu 4a (K4a)	7.62	7.41	38.5	77.11	77.9	154.87
Kithinu 4b (K4b)	7.46	7.96	46.2	86.32	170.2	172.88
Kithinu 5 (K5)	7.25	8.16	47.8	97.23	95.3	199.56

The results indicated that the water samples had a pH value range of 6.97 to 8.16, total dissolved solids (TDS) ranging from 34.6 ppm to 97.23 ppm and electrical conductivity (eC) ranged from 69.2 µS/cm to 199.56 µS/cm. Statistical analysis for pH, TDS and eC values indicated significant differences in values registered at various sampling sites at 95% confidence level. However only data in sampling points one and two were not significantly different as the sampling points were only 100m away from each other. TABLE 2 summarises the variances.

Table 2. Combined analytical results for Physicochemical parameters for water in the River Kithinu and River Mutonga

River Section	PH		TDS		eC	
	wet	dry	wet	dry	wet	dry
Kithinu 5 (K5)	8.193a	8.16a	47.7f	97.22b	95.3f	199.5b
Kithinu 4b(K4b)	7.96b	7.96b	46.2g	86.32c	170.2a	172.9c
Kithinu 1 (K1)	7.84c	7.84c	34.6i	54.22h	69.2h	110.1i
Kithinu 2 (K2)	7.84c	7.807c	34.6i	54.21h	69.2h	110.1i
Mutonga 3 (M3)	7.607d	7.673d	55.43c	84.16d	102.7d	167.9d
Kithinu 4a (K4a)	7.41e	7.41e	38.5h	77.11f	78.2g	154.9f
Kithinu 3 (K3)	7.33f	7.33f	69.9a	78.36e	142.6b	156.9e
Mutonga 5 (M5)	7.22g	7.22g	64.4b	97.29a	132.5c	201.9a
Mutonga 1 (M1)	6.97h	6.97h	49.6e	68.24g	94.1e	136.7h
Mutonga 2 (M2)	6.97h	6.937h	49.8d	68.24g	94.1e	136.8h
P value	<.001	<.001	<.001	<.001	<.001	<.001
SE	0.0204	0.0253	0.069	0.025	0.258	0.0315

3.2.2. Plant nutrients.

Nitrates values ranged from 0.21±0.00 ppm to 12.25±1.05 ppm, while phosphates values ranged from 7±0.01 ppb to 47±6.32 ppb. A summary of nitrates and phosphates values at various sampling points within the study area for the wet and dry season is as shown in TABLE 3.

Table 3 Levels of phosphates and Nitrates in the sampled sites during the wet season (April-May 2016) and dry season (august – september 2016).

sampling site	**nitrates (ppm) wet**	**nitrates (ppm) dry**	**phosphates (ppb) wet**	**phosphates (ppb) dry**
Mutonga 1	0.21±0.00	0.38±0.01	37±0.06	14±2.4
Mutonga 2	0.22±0.00	0.39±0.01	37±0.06	14±2.4
Mutonga 3	12.25±1.05	11.25±1.05	47±6.32	25±6.32
Mutonga 5	9.55±0.1	7.88±0.00	45±0.00	22±0.98
Kithinu 1	7.49±0.12	1.09±0.00	7±0.01	8±0.06
Kithinu 2	7.49±0.12	1.08±0.00	7±0.01	8±0.06
Kithinu 3	0.336±0.00	3.69±0.08	14±0.26	31±2.51
Kithinu 4a	2.17±0.03	7.62±0.45	32±1.94	22±1.84
Kithinu 4b	7.91±0.01	9.22±0.21	9±0.07	33±1.54
Kithinu 5	8.26±0.00	11.39±1.08	29±0.53	41±5.81

Mean ± standard deviation, n = 3

There was an increasing trend for values detected from up section to midsection and lower section of the irrigation projects. Values of nitrates detected in the Mutonga3 (M3) and Kithinu5 (K5) located within and after the irrigation projects were above the WHO limit for nitrates in drinking water. Statistical analysis for values at different sampling sites showed significant differences at 95% confidence level. However values in sampling points one and two were not significantly different as the sampling points were only 100m away from each other. A summary of the variances is as shown in TABLE 4.

Table 4. Combined analytical results for plant nutrients available in the River Kithinu and River Mutonga

River Section	**Nitrate**		**Phosphate**	
	Wet	**dry**	**wet**	**dry**
Mutonga 3(M3)	12.31a	11.25b	180a	25.1d
Mutonga 5(M5)	9.55b	7.87d	45b	22e
Kithinu 5(K5)	8.26c	11.39a	29b	41.0a
Kithinu 4(K4a)	7.91d	9.22c	9b	33b
Kithinu 1(K1)	7.49e	1.10g	7b	8g
Kithinu 2(K2)	7.49e	1.08h	7b	8g
Kithinu 4a (K4a)	2.17f	7.62e	32b	22.1e
Kithinu 3 (K3)	0.336g	3.69f	14b	31.1c
Mutonga 2 (M2)	0.22h	0.38i	37b	14f
Mutonga 1(M1)	0.217h	0.38i	37b	14f

P value	**<.001**	**<.001**	**0.027**	**<.001**
SE	**0.02716**	**0.00507**	**59.6**	**0.1018**

IV. DISCUSSIONS

During the period of study, there was an increasing trend for nitrates and phosphate values detected from up section to midsection and lower section of the irrigation projects. Statistical values also showed significance differences in the values detected (TABLE 4). Values detected in sampling points one and two located upstream section were lower than values at sampling points three, four and five located in midsection and lower section. This may be attributed to the high vegetation cover and riparian vegetation in the areas before the irrigation projects. However values of nitrates detected in the Mutonga3 (12.25±1.05, 11.25±1.05) and Kithinu5 (11.39±1.05) located within and after the irrigation projects were significantly different from the WHO standard values for drinking water of 10mg/l. These sampling points are catchment areas for both Maraa Kamuramba and Ng'urwe Gakirwe irrigation projects which registered a percentage of 25% and 11.8% of farmers respectively; with no soil conservation measures on their farms. Thus an indication of possible entry of runoff from the irrigated land into the river water [7]. Contamination of surface water may also be dependent on other factors such as the soil characteristics and climate of the area [9, 12]. Hence further investigations need to be considered.

The increasing trend was also noted with values of TDS and EC in the various sampling points (TABLE 1) and values were significantly different (TABLE 2). The study was able to show that poor farm management arising from agriculture activities such as lack of soil conservation measures and lack of riparian vegetation have interferences on water quality.

High levels of nitrates and phosphates in rivers have detrimental effects on the humans, animals and biodiversity. There is loss for water sources for domestic use, compounding the effects of water scarcity in Kenya [18]. High eutrophication of water bodies leads to algae bloom and consequent anoxic conditions in water [7]. Consumption of high levels of nitrates also affects human beings [13].Similar studies conducted on river Sosian in Uasin Gishu county Kenya indicates that agricultural activities have an impact on water quality deterioration, with increasing trend of turbidity, TDS, EC, nitrates and phosphates from upstream to downstream [19]. Studies conducted in Ngong-Motoine River in Kenya also attributes encroachment in river banks for agricultural activities and industrial activities to high levels of nitrates and phosphates in river water [20].Studies conducted earlier in Mituguu Irrigation project indicated a population of 25.4% not using any form of protection while applying agrochemicals [21]. This indicates that farmers have not fully embraced the use of PPEs despite the interventions through education hence other underlying factors.

V. CONCLUSIONS AND RECOMMEDATIONS

4.1. Conclusions

From the study, it can be concluded that poor farm management practices in the study area such as lack of soil conservation measures and protection of the riparian areas are contributing to presence of nitrates and phosphates residues in water in the study rivers. Nitrates levels in some sampling points located within and after the irrigation projects were above the WHO and KEBS limits for drinking water. Values of nitrates and phosphates at points located upstream of the irrigation projects registered values at safe limits. This upward trend for nitrate and phosphate values detected from sampling points located up section to mid section and lower section of the irrigation projects is an indication of possible entry of runoff into the rivers. Despite a population slightly above average of farmers having very good and good levels of knowledge on use of PPEs, a high population of farmers still use old clothes as PPEs while others do not use any form of PPEs during application of agrochemicals. This may have negative effects on the health of the farmers. Hence the need to investigate other underlying factors that lead to the low embracement on use of PPEs. The study will act as a guideline for small holder irrigation farmers on the need to embrace good farm management practices and hence control water quality deterioration. Regular environmental monitoring programs of pollutants into the water bodies is also necessary to manage water quality deterioration as a result of irrigation activities and hence sustainable production.

REFERENCES

[1]. Government of Kenya [GOK], Kenya Vision 2030, (Nairobi: Government Printer, 2007).
[2]. United Nations (UN), Millennium Development Goals (MDG) report, (United Nations, New York, 2014).
[3]. United Nations (UN), Millennium Development Goals (MDG) report, (United Nations, New York, 2015).
[4]. Food and Agriculture Organisation [FAO], Control of water pollution from agriculture, (Rome, 1998).
[5]. Ministry of Agriculture, Livestock and Fisheries (MOALF), MOALF achievements under the Jubilee government's one year in office, (Nairobi: Government Printer, 2014).
[6]. Horticultural Crops Development Authority [HCDA], Horticulture Validate report, (Ministry of Agriculture and HCDA, Nairobi, Kenya, 2012).
[7]. O. D. Tyagi, & M. Mehra, A Text book of Environmental Chemistry, (India: Vikas Publishing house, 1992).

[8]. Scottish Executive, Prevention of Environmental Pollution from Agricultural Activity. Code of practice, (Edinburgh: St Andrew's House, 2005).
[9]. Food and Agriculture Organisation [FAO], Introduction to Agricultural water pollution, (Rome, 2008).
[10]. O. A. Afullo, Irrigation suitability assessment of effluents from West Kano rice irrigation scheme, Kisumu, Kenya, Ethiopian Journal of Environmental Studies and Management, 2 (2), 2009, 30- 45.
[11]. H. Harieth, Pesticide residues in four rivers running through an intensive agricultural area, Kilimajaro, J. Appl. Sci. Environ. Management,
5 (2), 2011, 307 - 316.
[12]. Otago Regioanal Council, The effect of irrigation runoff on water quality. Irrigation runoff report. (ISBN: 1-877265-40-3, 2006)
[13]. US EPA, Protecting water quality from agricultural runoff, (EPA 841-F-05-001, 2005).
[14]. C. R. Kothari, Research Methodology (2nd ed.), (New Delhi: New age international (p) Ltd, 2004).
[15]. American Public Health Association [APHA], Standard methods for the examination of water and wastewater (22nd ed.), (Washington, DC. , 1995).
[16]. World Health Organisation [WHO], Drinking Water Quality: (3rd e.d.). Vol 3., (WHO, Geneva, 2008).
[17]. World Health Organisation [WHO], Guidelines for drinking-water Quality: (3rde.d.). Vol 1., (WHO, Geneva, 2008).
[18]. Water Resources Management Authority [WRMA], Strengthening regulations for sustainable water resources management in Kenya. (Nairobi: Government Printer, 2015).
[19]. Ontumbi G. M., Obando J. and Ondieki C., The influence of agricultural activities on the water quality of the River Sosiani in Uasin Gishu county, Kenya, International Journal of research in agricultural sciences, 2(1), 2015, ISSN: 2348-3997
[20]. Nangulu E. , Mapping spatial -temporal variations of phosphates, sulphates, Nitrates and Escherichia Coli in Ngong River, Kenya, Msc thesis, University of Nairobi, Department of Chemistry, 2015.
[21]. E.O. Monda, S. Munene & A. Ndegwa, French beans production constraints in Kenya, Proc. African Crop Science, Uganda, 2003, 6 683-687.

Wambugu A.W. "Impacts of Farm Management Practices on Levels of Nitrates And Phosphates in water Along the Kithinu And Mutonga Rivers Catchment Areas, Kenya." Quest Journals Journal of Research in Environmental and Earth Science, vol. 03, no. 05, 2017, pp. 75–82.