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ASSESSMENT OF AGROCHEMICALS EFFECT ON SOIL AND GROUNDWATER OF *CHANCHAGA* IRRIGATION SCHEME IN MINNA, NORTH CENTRAL NIGERIA

Adeoye, Peter Aderemi[a*], Hasfalina Che Man[b], Abdulahi Mohammed Bello[c]

[a]Department of Agricultural and Bioresources Engineering, Federal University of Technology, Minna, Nigeria
[b]Department of Biological and Agricultural Engineering, University Putra, Darul Ehsan, Selangor, Malaysia
[c]Niger State Ministry of Science and Technology, Minna, Nigeria

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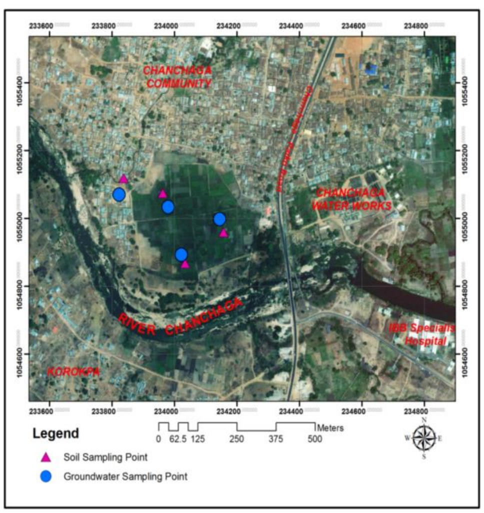
*Corresponding author
pheterhardey@yahoo.com

Graphical abstract



Abstract

A study was conducted to assess the effects of long term usage of agrochemicals on soil and groundwater of *Chanchaga* Irrigation Scheme. Soil and groundwater samples were collected from the scheme for the period of sixteen months and were analysed for NO_3, PO_4, Cl, K using UV Spectrophotometer and flame photometer and for some heavy metals, Mn, Zn and Cr using Atomic Absorption Spectrophotometer (AAS). The data were subjected to regression and correlation analysis and Analysis of Variance (ANOVA). The results show excessive presence of NO_3, PO_4, Mn, Zn and Cr in both the soil and water samples. It was observed statistically that all the chemical parameters (NO_3, PO_4, Mn, Zn and Cr) were significantly different at $p \leq 0.05$ in both groundwater and soil of *Chanchaga* Irrigation Scheme. The concentration of Nitrates and Phosphates ranged between 48.45 - 51.63 mg/l and 0.39 - 0.78 mg/l respectively in the water. This could be associated with the used of agrochemicals and fertilizer that are Nitrogen and Phosphorus based by the farmers. Zinc concentration ranged between 0.18-1.84 mg/l in the groundwater. On the average the concentration of manganese and chromium detected differ from one point of collection to the other. However, the concentration ranged between 0.22-0.53 mg/l with the highest concentration of 0.53 mg/l in points 2 and 3 where intensive agricultural practice is being carried out. Chromium concentration ranged between 0.18 - 0.29 mg/l. The chemical residues in the control site for Nitrate, Phosphate, Manganese, Zinc and Chromium were 48.45 mg/l, 0.39 mg/l, 0.21 mg/l, 0.18 mg/l and 0.04 mg/l respectively which were within the permissible limit. A safe depth of 8m was established statistically for future shallow wells that will guarantee potable water on the irrigation scheme. It is recommended that, to forestall further accumulation of these chemical residues in both soil and shallow groundwater of *Chanchaga* irrigation scheme, relevant regulatory Government agencies should enforce standard Good Agricultural Practice whereby the farmers are compelled to adhere strictly to existing standard for agrochemical and fertilizer application rate. Also future shallow wells to be constructed on the irrigation scheme must be up to 8 m in depth to guarantee nitrate and chloride free water.

Keywords: Agrochemicals, soil pollution, shallow groundwater and shallow well depth

INTRODUCTION

In Nigeria, agriculture belongs to major sector of economy. The roles of agriculture remain noteworthy in the Nigerian economy despite the strategic importance of the oil sector. Agriculture provides primary means of employment for many Nigerians and accounts for more than one-third of total Gross Domestic Product (GDP) and labour force [1,2] It is also obvious that the physical, chemical with the biological integrity of our planet is being compromised daily due to this intense agricultural production. The destructive processes are increasing both in quantity and in rate of agrochemicals application which are important agricultural inputs to protect crops from diseases, pests and weeds. The uses of agrochemicals contribute not only to healthy growth of crops and animals but also to improve farm work efficiency and stable supply of agricultural produce [3].

Modern agriculture relies heavily on herbicides for the control of weeds in crops and pastures to maximize yields and economic benefits to sustain increasing world population. The introduction of herbicide-resistant traits in several crops, such as glyphosate-resistant (GR) soya bean, maize and canola, has further increased herbicide consumption worldwide [4]. However, the negative impacts of agrochemicals have resulted in loss of biodiversity and destruction of natural habitat and pollution of surface and groundwater [5]. The environmental fate of herbicides is a matter of recent concern given that only a small fraction of the chemicals reach the target organisms leading to potential impacts of residual herbicides in soil and water has on human, animal and crop health.

Herbicides are used far more than other types of pesticides and they become so popular that many farmers and gardeners depend solely on it for controlling weeds. Herbicides sometimes contain ingredients that are poisonous to humans and other organisms [2]. Atrazine, for example, the most widely used agricultural herbicide, promotes the imbalance of estrogen, which has been linked to breast cancer Though Pesticides are beneficial, inappropriate use can be counter-productive and threaten the long-term survival of major ecosystems by disruption of predator-prey relationships, loss of biodiversity, increase pest resistance and kill the natural enemies of pests and can have significant human health consequences [6] and hence should essentially be subject to safe and judicious use. Most farmers in the study area make use of agrochemical in large quantities. This is because what the farmers are after is to protect the crop from insect attack and to have high yield. These operations are carried out without considering the negative effects of the substances applied to the soil, as well as to the surface and ground water systems. The most recent guideline in Nigeria by the Federal Environmental Protection Agency [7] is about two decades old and urgently need updating. Hence the need to carry out this research so as to assess the effect of the agrochemicals applied. Information on their use, distribution and environmental impacts is scanty in Nigeria. The objectives of this research are therefore to examine the concentration of agrochemical constituents in the soil and shallow groundwater of *Chanchaga* irrigation scheme and to determine a minimum safe depth for wells to yield potable groundwater that is not polluted with agrochemicals in *Chanchaga* Irrigation Scheme.

MATERIALS AND METHODS

Study Location

Chanchaga irrigation scheme in Minna, Niger state Nigeria was used for this study. The location lies between latitude 9°36'50"N and longitude 6°33'25"E and stretched along the bank of *Chanchaga* river. (Figure 1). *Chanchaga* irrigation scheme was established in the early 1980s, covering 15 hectares of arable farmland with furrow irrigation commonly practiced. *Chanchaga* irrigation scheme site experiences two distinct seasons, the dry and wet seasons. The annual rainfall varies between 1200mm and 1600mm. The duration of the wet season ranges from 150 – 210 days. *Chanchaga* has a minimum average temperature of 27.6^{0}C and a maximum average temperature of 38.2^{0}C [8]. The vegetation of Minna and its environs are characterized by presence of tall grass and the trees which are scattered and deciduous. Arable farming is mostly carried out within *Chanchaga* and environs, crops like yam, millet, melon and rice are cultivated on the scheme. Vegetables like spinach, okra, roselle, tomatoes and other essential vegetables are also cultivated on the scheme.

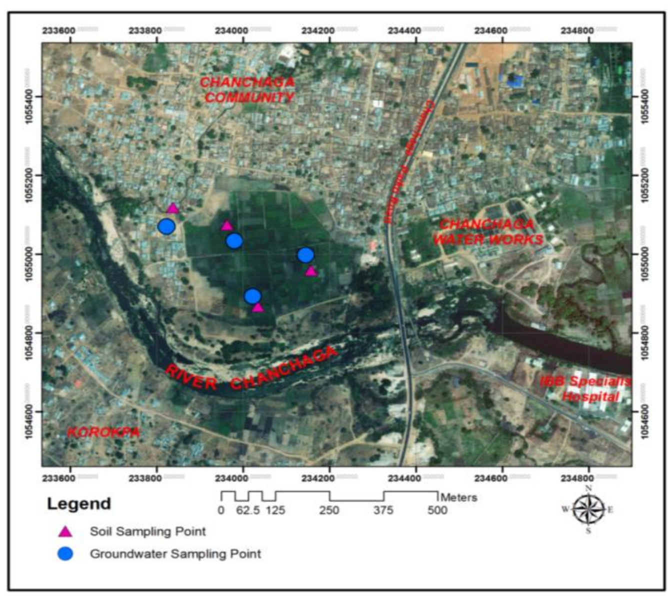


Figure 1 Map of study area and the sampling points

The irrigation scheme according to [8] serves the population of about 21,140 with an annual growth rate of 3.4%.

Experimental Design

Multilevel Factorial Design was used. Four sampling points for six months collection periods (4 x 6) with base runs of 24 and 3 replications which consist of a total runs of 144 was considered. Data and information that centre on the application of agrochemical were collected from farmers and Agricultural Development Scheme. Some of these data are attributes of agrochemicals and their characteristics. The sources of data were from individuals, co-operate organization and agencies that are stakeholders in the issues of agricultural practices. A structured questionnaire was also used for data collection. The questionnaire centres on the issue of agrochemical and its uses. Questions pertaining to the issues of agrochemical use and dosage were asked. This provided information base for a comprehensive study. A reconnaissance survey of *Chanchaga* irrigation scheme was carried out in order to ascertain the actual hazards present in the study area and the relationship with the predisposing factors. Personal interview was conducted for some respondents to provide a suitable platform for interacting with the respondents on issues of agrochemicals impact.

Collection of Ground Water and Soil Samples

Ground water samples were collected in plastic containers from four wells, each dug to 3 meter depth on the irrigation field and one existing well 100m outside the irrigation field serving as the control. The samples were taken to laboratory and analysed for physico-chemical parameters. Soil samples at depth of 30cm were also collected from three points from the intense agricultural area and one from the control plot 100m away from the intense agricultural area. The samples were properly covered and taken to the laboratory for digestion and analysis using standard procedures.

RESULTS AND DISCUSSION

Tables 1 and 2 present the results for physico-chemical parameters for soil and groundwater samples collected from the irrigation scheme.

Table 1 Chemical parameters of water samples from the shallow wells

Month	Treatment	Cl (mg/L)	NO_3(mg/L)	PO_4(mg/L)	Mn (mg/L)	Zn(mg/L)	Cr(mg/L)
July	Control	27.4 ± 0.5	33.1 ± 0.1	0.3 ± 0.0	0.2 ± 0.1	1.7 ± 0.1	0.01 ± 0.0
	Point 1	105.9 ± 0.2	51.6 ± 0.3	0.4 ± 0.0	0.3 ± 0.0	12.6 ± 0.1	0.10 ± 0.0
	Point 2	64.8 ± 0.2	51.7 ± 0.8	0.5 ± 0.0	0.2 ± 0.0	9.4 ± 0.3	0.10 ± 0.0
	Point 3	55.9 ± 0.1	50.9 ± 0.2	0.5 ± 0.0	0.3 ± 0.0	8.6 ± 0.2	0.10 ± 0.0
August	Control	75.2 ± 0.1	26.3 ± 0.1	0.4 ± 0.0	0.2 ± 0.1	1.6 ± 0.0	0.01 ± 0.0
	Point 1	100.5 ± 0.5	65.4 ± 0.1	0.5 ± 0.0	0.3 ± 0.0	12.5 ± 0.2	0.06 ± 0.0
	Point 2	100.9 ± 1.1	66.2 ± 0.1	0.5 ± 0.0	0.3 ± 0.0	12.8 ± 0.2	0.10 ± 0.0
	Point 3	98.2 ± 0.2	60.0 ± 0.1	0.5 ± 0.0	0.3 ± 0.0	15.8 ± 0.2	0.07±0.0
September	Control	75.2 ± 0.1	21.1 ± 0.5	0.4± 0.0	0.2 ± 0.0	2.1 ± 0.1	0.05 ± 0.0
	Point 1	90.5 ± 0.5	53.1 ± 5.7	0.7± 0.0	0.3 ± 0.0	8.8 ± 0.3	0.10 ± 0.0
	Point 2	90.9 ± 1.1	56.3 ± 0.3	0.8± 0.0	0.4 ± 0.0	13.1 ± 0.1	0.02 ± 0.1
	Point 3	98.2 ± 0.2	53.1 ± 0.1	0.7± 0.0	0.3 ± 0.0	10.7 ± 0.2	0.10 ± 0.0
October	Control	27.4 ± 0.5	18.6 ± 0.3	0.4± 0.0	0.2 ± 0.0	1.1 ± 0.0	0.03 ± 0.0
	Point 1	105.9 ± 0.2	51.4 ± 0.1	0.5± 0.0	0.3 ± 0.0	6.1 ± 0.0	0.08 ± 0.0
	Point 2	64.8 ± 0.2	50.9 ± 0.3	0.5± 0.0	0.2 ± 0.1	7.4 ± 0.0	0.06 ± 0.0
	Point 3	55.9 ± 0.1	50.8 ± 0.2	0.5± 0.0	0.3 ± 0.0	2.4 ± 0.0	0.10 ± 0.0
November	Control	35.3 ± 0.3	11.5 ± 0.1	0.5± 0.0	0.2 ± 0.0	1.7 ± 0.2	0.03 ± 0.0
	Point 1	53.7 ± 0.7	39.2 ± 0.0	0.5± 0.0	0.3 ± 0.0	3.6 ± 0.2	0.06 ± 0.0
	Point 2	54.8 ± 0.2	40.4 ± 0.1	0.5± 0.0	0.3 ± 0.0	8.8 ± 0.2	0.10± 0.0
	Point 3	56.3 ± 0.3	39.0 ± 0.1	0.5± 0.0	0.3 ± 0.0	3.8 ± 0.2	0.10 ± 0.0
December	Control	49.8 ± 0.6	29.4 ± 0.1	0.5± 0.0	0.2 ± 0.1	1.7 ± 0.2	0.03 ± 0.0
	Point 1	59.9 ± 0.2	36.4 ± 0.0	0.5± 0.0	0.3 ± 0.0	2.6 ± 0.2	0.06 ± 0.0
	Point 2	44.8 ± 1.1	38.3 ± 0.0	0.5± 0.0	0.3 ± 0.0	3.8 ± 0.2	0.10 ± 0.0
	Point 3	33.4 ± 0.6	34.6 ± 0.1	0.5± 0.0	0.3 ± 0.1	6.8 ± 0.2	0.07 ± 0.1

Results are mean of three replicates ± standard deviation

Prior to soil samples digestion and analysis, textural classification was conducted and the results revealed that the soil belongs to sandy clay loam with sand, clay and silt percentage of 53%, 32% and 15% respectively.

Table 2 Chemical parameters of soil samples from the study location

Month	Treatment	Cl(mg/kg)	NO_3(mg/kg)	PO_4(mg/kg)	Mn(mg/kg)	Zn(mg/kg)	Cr(mg/kg)
July	**Control**	41.5 ± 0.1	49.3 ± 0.4	0.4 ± 0.1	0.1 ± 0.0	91.7 ± 0.1	1.1 ± 0.0
	Point 1	23.5 ± 2.3	51.8 ± 0.5	1.6 ± 0.1	1.3 ± 0.03	102.7± 0.1	1.2 ± 0.0
	Point 2	37.9 ± 0.1	51.5 ± 1.1	1.5 ± 0.1	1.3 ± 0.0	102.4± 0.3	1.4 ± 0.0
	Point 3	41.5 ± 0.3	51.6 ± 0.5	1.5 ± 0.0	1.2 ± 0.0	102.6± 0.2	1.4 ± 0.0
August	**Control**	41.6 ± 0.3	45.9 ± 1.8	0.4 ± 0.1	0.5 ± 0.0	99.9 ± 0.1	1.4 ± 0.0
	Point 1	107.7 ± 0.3	50.8 ± 0.6	0.7 ± 0.0	0.8 ± 0.1	103.9± 5.1	1.5 ± 0.0
	Point 2	52.4 ± 0.0	50.9 ± 0.6	0.5 ± 0.0	1.6 ± 0.1	106.9± 0.9	1.6 ± 0.2
	Point 3	85.6 ± 0.3	50.7 ± 0.3	1.2 ± 0.6	1.1 ± 0.0	107.1± 0.3	2.1 ± 0.0
September	**Control**	28.4 ± 0.1	50.8 ± 0.0	0.3 ± 0.0	0.2 ± 0.0	96.1 ± 1.2	1.2 ± 0.0
	Point 1	96.3 ± 0.3	53.7 ± 0.2	0.6 ± 0.0	0.3 ± 0.0	111.6± 0.5	1.8 ± 0.0
	Point 2	60.7 ± 0.1	56.0 ± 0.2	0.5 ± 0.0	0.3 ± 0.0	106.1± 0.1	1.7 ± 0.1
	Point 3	55.6 ± 0.4	53.3 ± 0.4	0.5 ± 0.1	0.6 ± 0.1	99.5 ± 0.1	1.7 ± 0.1
October	**Control**	41.4 ± 0.1	48.2 ± 0.3	0.3 ± 0.1	0.2 ± 0.1	91.6 ± 1.7	1.2 ± 0.0
	Point 1	28.4 ± 0.1	51.3 ± 0.8	1.4 ± 0.1	1.2 ± 0.0	110.3± 0.6	1.9 ± 0.1
	Point 2	38.0 ± 0.1	50.8 ± 0.2	1.5 ± 0.0	1.1 ± 0.1	108.5± 0.5	1.8 ± 0.0
	Point 3	41.5 ± 0.1	51.3 ± 0.5	1.5 ± 0.2	0.5 ± 0.1	109.8± 0.7	1.8 ± 0.1
November	**Control**	41.4 ± 0.0	50.0 ± 0.0	0.4 ± 0.2	0.3 ± 0.0	99.5 ± 0.1	1.3 ± 0.1
	Point 1	104.8 ± 0.4	51.2 ± 0.1	0.9 ± 0.2	0.7 ± 0.2	100.8± 0.1	1.4 ± 0.3
	Point 2	53.8 ± 0.5	51.3 ± 0.2	1.5 ± 0.1	0.5 ± 0.0	106.9± 0.9	1.6 ± 0.1
	Point 3	85.7 ± 0.3	50.7 ± 0.1	0.6 ± 0.1	0.6 ± 0.1	107.1± 0.2	1.4 ± 0.2
December	**Control**	41.4 ± 0.0	50.0 ± 0.0	0.4 ± 0.2	0.3 ± 0.0	99.5 ± 0.2	1.3 ± 0.1
	Point 1	104.8 ± 0.4	51.2 ± 0.0	0.9 ± 0.2	0.7 ± 0.2	100.8± 0.1	1.4 ± 0.3
	Point 2	53.8 ± 0.5	51.3 ± 0.2	1.5 ± 0.1	0.5 ± 0.1	106.9± 0.9	1.6 ± 0.1
	Point 3	85.7 ± 0.3	50.8 ± 0.1	0.6 ± 0.0	0.6 ± 0.1	107.1± 0.2	1.4 ± 0.2

Results are mean of three replicates ± standard deviation

Variation of Nitrates in the Shallow Wells

Figure 2 present variation of nitrate in shallow wells with months of collection. It was observed that, nitrate concentration was within WHO permissible limits. in the November and December and this can also be attributed to the evaporation that takes place within this period. In extreme cases nitrate has a symptom of bluish dis-colouration of the infant referred to as blue-baby syndrome (*methemoglobinemia*) as a result of its accumulation while severe concentration of nitrate in adults can lead to cancer of respiratory organs. [9].

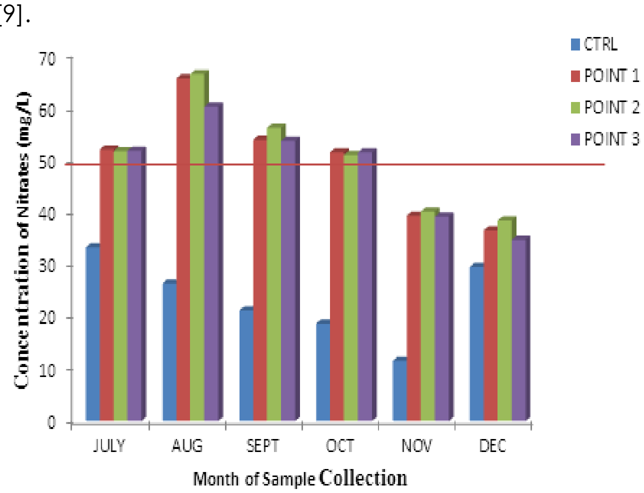


Figure 2 Variation of nitrates in shallow wells

control throughout the months of collection while Nitrate concentration exceeded the maximum permissible limit in point 1, point 2 and point 3 throughout the months of July, August, September and October but falls below the MCL in the months of From Figure 3, water collected from the wells throughout the months of July, August and September. Points 2 and 3 in October, point 2 in November and point 3 in December are not fit for consumption due to high zinc concentration which was above the maximum permissible limit of 5mg/l but the control from the month of July to December, point 3 in October, points 1 and 3 in November and points 1 and 2 in December are fit for consumption with respect to zinc concentration. The high amount can be as a result of the application of high quantity of zinc based agrochemical and this if consumed in high amount can lead to cancer and other health disorder. [11]

As shown in Figure 4, regression equations of Nitrate and Chloride respectively with well depths showed that the concentration of nitrate and chloride increases in the water sample at the shallow levels of the wells on the intensive agricultural area. This could be associated to the high level of the application of these agrochemicals on the farmland but decreases as the well depth goes deeper probably as a result of filtration capacity of Minna soil [9]. These finding is also in line with results of [10]. Applying the evaluation method of [11] to the regression equations taking MCL of nitrate to 50mg/l and that of chloride as 250mg/l, it was calculated that for the well on *chanchaga* irrigation scheme to be relatively free from these chemicals residues the wells should be 7.7 m deep for nitrate and 7.8 m deep for chloride. Therefore minimum safe depth was then recommended to be 8 meters.

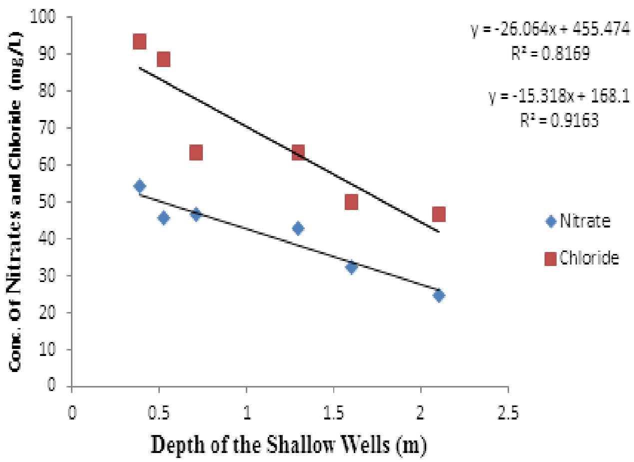


Figure 4 Correlation of nitrate and chloride with depth

Table 3 presents the inter-elemental correlation indicates that at (*p<0.05*) there was a significant difference between the depth of water and these elements: chloride, nitrate, phosphate and zinc which shows that as the depth of water reduces the elements increases in the water content, this could be as a result of high amount of these substances applied on the farmland and also depicts that depth plays a vital role in keeping the water in the wells of intensive agricultural area safe as reported by [12].

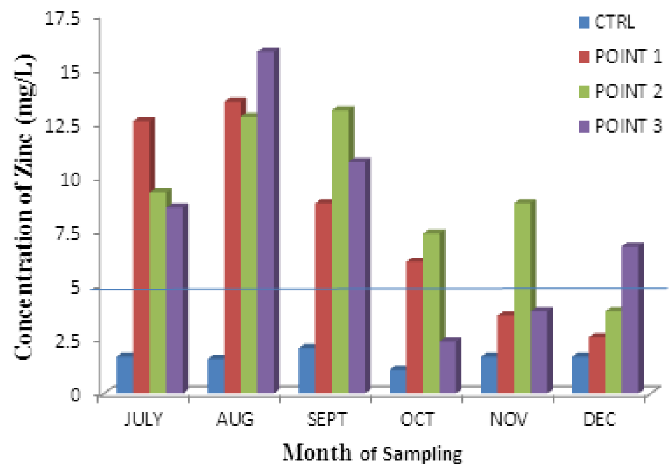


Figure 3 Concentration of zinc in the groundwater samples

Table 3 Pearson's inter-elemental correlation among water samples parameters

	Depth	***Cl***	***NO₃***	***PO₄***	***Mn***	***Zn***	***Cr***
Depth	1						
Cl	-0.59*	1.00					
NO₃	-0.87**	0.72**	1.00				
PO₄	-0.75**	0.39	0.84**	1.00			
Mn	0.04	0.64*	0.62*	0.63*	1.00		
Zn	-0.82**	0.72**	0.83**	0.66*	0.57*	1.00	
Cr	0.31	0.10	0.60*	-0.08	0.02	0.63*	1

**Correlation is significant, **Correlation is highly significant at p< 0.05 (2 – tailed)*

Other inter- elemental correlations (Table 2) exist. For instance, strong positive correlation exists between nitrate and chloride, manganese and chloride, zinc and chloride, phosphate and manganese. [13] explained this to mean a very strong affinity and implies that any activities, either anthropogenic or otherwise that enhance build-up of any one of parameters that are inter-related will lead to a build-up of the other parameter in that medium. By implication this depict that the shallow groundwater of *Chanchaga* irrigation is not potable for consumption because it poses threat to human health.

Table 4 present the summary of the overall statistical result obtained using SAS (16.0) model on the month, medium and the sampling points of the research work.

Table 4 Statistical results on the groundwater and soil

Variation Source	**DF**	**Cl**	**NO₃**	**PO₄**	**Mn**	**Zn**	Cr
Month (MT)	5	5185.30**	8.49*	0.52**	0.31**	4.09NS	0.14**
Medium (M)	1	1294.62*	29.39**	4.02**	5.27**	375283.86**	87.52**
SP	3	8157.88**	77.02**	1.32**	0.91**	310.60**	0.74**
MT x M	5	1525.04**	18.23**	0.85**	0.45**	15.61*	0.16**
MT x SP	15	789.43**	5.68**	0.13**	0.069**	28.42**	0.13**
M x SP	3	40.14NS	0.81NS	0.54**	0.41**	238.83**	0.58**
Error	99	162.50	1.47	0.03	0.015	5.07	0.019

Values on the same column for same parameters with (*) are significantly different at (p≤0.05), while those with (**) are highly significantly different at (p>0.05). SP = Sampling points.

Table 5 Effect of month on chemical parameters in Groundwater

Month	Cl	NO_3	PO_4	Mn	Cr
July	41.24^{e}	50.31^{cb}	0.84^{a}	0.60^{a}	0.96^{a}
August	70.15^{b}	50.25^{cb}	0.59^{c}	0.56^{a}	0.86^{b}
September	55.16^{cd}	51.57^{a}	0.56^{cd}	0.32^{c}	0.86^{b}
October	50.43^{d}	49.88^{c}	0.84^{a}	0.46^{b}	0.88^{b}
November	82.57a	50.87^{b}	0.70^{b}	0.38^{c}	0.72^{c}
December	58.90^{c}	50.79^{b}	0.50^{d}	0.36^{c}	0.84^{b}
SE ±	2.60	0.25	0.03	0.02	0.03

Values on the same column for same parameters with different superscript are significant at ($p \leq 0.05$), while those with the same superscript are not significantly different ($p>0.05$)

From Tables 4 and 5, there are significant differences between the parameters and the months of soil samples collection. This according to [14] may be attributed to uneven distribution of rainfall and sunshine in the months under consideration. Excessive rainfall may lead to dilution of the parameters while long hour of sunshine will increase evaporation and by implication the concentration of the parameters. [15] recorded this type of relationship and then opined that for a definite relationship of soil parameters to be ascertained in an agricultural field with excessive agrochemicals use, samples should be collected and analysed for a very long period of time.

Table 6 Effect of medium on chemical parameters

Medium	Cl	NO_3	PO_4	Mn	Zn	Cr
Groundwater	42.74^{a}	41.06^{a}	0.51^{a}	0.26^{b}	2.12^{b}	0.07^{b}
Soil	56.74^{b}	50.16^{b}	0.84^{b}	0.64^{a}	104.22^{a}	1.63^{a}
SE ±	1.5	0.14	0.02	0.04	0.27	0.02

Values on the same column for same parameters with different superscript are significant at ($p \leq 0.05$), while those with the same superscript are not significantly different ($p>0.05$)as assessed by Duncan's Multiple Range Test.

From Table 6, significant difference was also observed between groundwater and soil of *Chanchaga* Irrigation Scheme but with higher average values in soil more than water samples. [16] after studying the mechanism of solute release from soil to water concluded that soil normally act as temporary reservoir for water contaminating solute and anytime there is water movement from soil, it will wash this solute of soil and make the water to be contaminated. Therefore, if water samples from *Chanchaga* would be clean up of these agrochemical constituents, the soil would have to be prevented from residual solute by adhering to agrochemical application recommended dosage.

Table 7 Effect of sampling point on chemical parameters

Sampling Points	Cl	NO_3	PO_4	Mn	Zn	Cr
Control	42.38^{d}	48.45^{b}	0.39^{b}	0.21^{b}	0.18^{c}	0.04^{c}
Point 1	78.30^{a}	51.31^{a}	0.76^{a}	0.52^{a}	1.84^{a}	0.29^{a}
Point 2	55.06^{c}	51.63^{a}	0.78^{a}	0.53^{a}	1.82^{ab}	0.18^{b}
Point 3	63.23^{b}	51.05^{a}	0.76^{a}	0.53^{a}	1.70^{b}	0.20^{b}
SE ±	2.12	0.20	0.03	0.02	0.38	0.02

Values on the same column for same parameters with different superscript are significant at ($p \leq 0.05$), while those with the same superscript are not significantly different ($p>0.05$).

From the result presented in Table 7, NO_3, PO_4, Mn, Zn and Cr were all detected in the samples collected. The concentration of Nitrate and Phosphate ranged between 48.45-51.63 mg/l and 0.39-0.78 mg/l. the highest concentration were 51.63 mg/l and 0.78 mg/l were obtained in points 2. This could be associated with the used of agrochemicals and fertilizer that are Nitrogen and Phosphorus based by the farmers. In addition to this, Zinc ranged between 0.18-1.84 mg/l on the intensive agricultural area. The highest concentration 1.84 mg/l in point 1 compared with the values in the other points is expected because it has been reported that zinc occurs at high concentration in Nigeria soil, [17]. On the average the concentration of manganese and chromium detected differ from one point of collection to the other. Similar variation was reported by [18]. While all the control falls within the [19] permissible limit.

Results from administered questionnaires revealed that most farmers are relatively less educated; their ability to absorb professional knowledge is weaker. Furthermore, their capability to recognize correct dosage application of the agrochemicals will be of great concern. Hence, the less-educated farmer tends to lack awareness of both agrochemical residues and the importance of applying agrochemical in correct dosage. Consequently, with less education, there is a higher chance that the farmer will apply prohibited agrochemical excessively, leading to highly concentrated agrochemical residues. Figure 5 present the types of agrochemicals used by the farmers and the length of time the farmers have been applying them. The common agrochemicals used on *Chanchaga* scheme include herbicides, rodenticides, insecticides and fertilizer. Insecticides and fertilizer were the most often used agrochemicals on the scheme because all the interviewed farmers apply them while herbicides and rodenticides were applied by only 42% of the farmers.

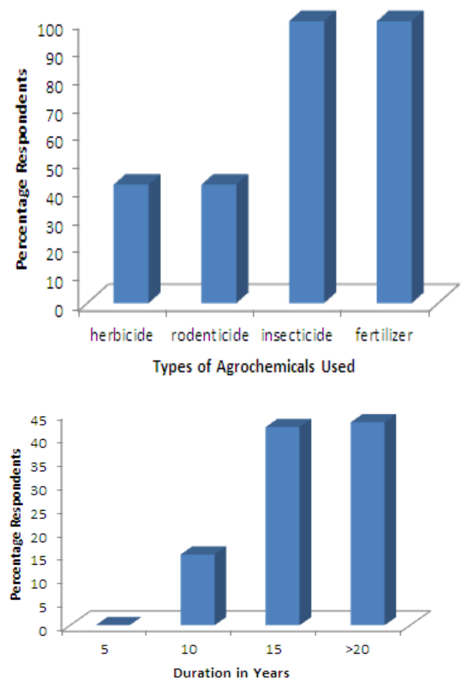


Figure 5 Types of agrochemicals applied and duration of application

It was also observed that farmers have been applying these agrochemicals since the inception of the irrigation scheme. Forty three per cent has been farming and applying these chemicals for over 20 years, 42% for 15 years, 15% for 10 years and 0% for 5 years, with these quantum of agrochemicals applied on the farmland over these periods of years would have led for the accumulation of these chemicals into the soil and groundwater [15]. Figure 6 showed the quantity of agrochemicals and fertilizers applied per hectare which also showed that the quantity have exceeded the recommended dosage as reported by [20]. The report recommended 3-4 litres of liquid agrochemical per hectare, but forty two per cent of the farmers applied above the recommended dose per hectare, 28% applied 4 litres, 30% applied 3 litres while zero per cent applied 2 litres per hectare. These may be the cause for the high concentration of the chemicals and pollution of the groundwater and soil of the irrigation scheme as a result of residual chemicals.

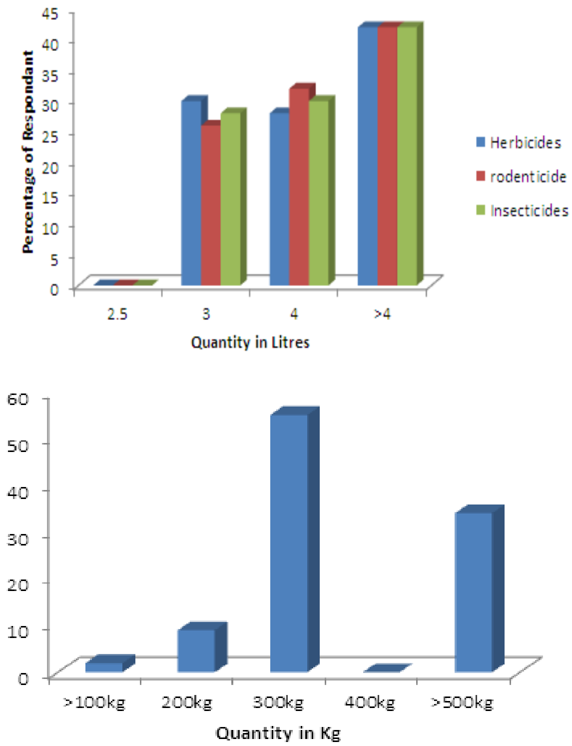


Figure 6 Quantity of agrochemicals and fertilizers applied in litres per hectare

It was also observed that 2% of the farmers applied >100kg of fertilizer per hectare of their farmland, 9% applied 200kg per hectare, 55% of the farmers applied 300kg per hectare, 0% applied 400kg per hectare while 34% applied >500kg per hectare. The result shows that more farmers applied 300kg per hectare which was more than the recommended dosage per hectare as was reported by [21].

CONCLUSION

From the results obtained, the concentration of NO_3, PO_4, Mn, Zn and Cr in both soil and groundwater were found to be above the maximum contaminant level (MCL) by WHO/FAO 2004. The parameters were found to be more on the main plots than the control plots where values less than MCL were recorded. This has potential fatal consequences to human health. It is therefore recommended that farmers should strictly abide by the standard agrochemicals application rate per hectare to reduce the excessive accumulation of the residue and heavy metal in the soil and groundwater. Future shallow wells in *Chanchaga* irrigation scheme should be at least 8 m depth to make the water safe for consumption and enlightenment campaign is recommended to be organized on the effects of excessive application of agrochemicals on the farmland.

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