Concentration Weathering of some Agrochemicals in Runoff and Soil Interface on the National Centre for Agricultural Mechanization (NCAM) Farm, Ilorin, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Original Research Article

ABSTRACT

Agrochemicals are needed to boost agricultural productivity, but substantial quantities are either transported into surface water through runoff or leached into groundwater, which may eventually lead to environmental degradation and pollution. Although several studies have been carried out on the effects of agrochemicals o soil and water qualities but the rate of dissipation of agrochemicals

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along their pathways are not fully understood yet. The aim of this study therefore was to investigate the level of dissipation of agrochemical elements and compounds as they moved along the furrow. Four experimental fields - NPK fertilizer, urea fertilizer, pesticides (organochlorine) and herbicides (glyphosate) were prepared for this study. The selected agrochemicals were applied on the experimental field and the concentration of chemical elements (electrical conductivity, pH, nitrogen, phosphorus, manganese, zinc, magnesium, potassium, glyphosate and organochlorine) along the furrow were measured at intervals (1 m on a 20 m row) using standard techniques. The range of electrical conductivity, pH, nitrogen, phosphorus, manganese, zinc, magnesium and potassium concentrations for runoff from NPK fertilizer applied field were: 95.75 - 174.51 µS/cm, 5.72 - 7.54, 0.21 - 0.68%, 0.09 - 0.36%, 0.1 - 0.47 mg L^{-1}, 0.25 - 0.66 mg L^{-1}, 4.63 - 7.88 mg L^{-1} and 7.28 - 16.15 mg L^{-1}; for runoff from Urea fertilizer applied field, the range were: 176.25 - 186.33 µS/cm, 7.14 - 7.64, 0.21 - 0.48 %, 0.21 - 0.38%, 0.41 - 0.65 mg L^{-1}, 0.23 - 0.49 mg L^{-1}, 5.48 - 7.64 mg L^{-1} and 8. 23 - 10.46 mg L^{-1}. The range of electrical conductivity, pH, nitrogen, phosphorus, manganese, zinc and magnesium concentrations for runoff from glyphosate applied field were: 114.00 - 283.78 µS/cm, 6.49 - 7.82, 0.13 - 0.67 mg/kg, 0.03 - 0.09%, 0.41 - 1.60 mg L^{-1}, 0.45 - 2.59 mg L^{-1}, 8.35 - 12.76 mg L^{-1}; and for runoff from organochloride applied field the range were: 344.37 - 380.48 µS/cm, 6.66 - 7.86, 0.30 - 0.56 mg/kg, 0.05 - 0.18%, 0.68 - 0.91 mg L^{-1}, 0.81 - 1.45 mg L^{-1} 12.48 - 14.68 mg L^{-1}. The concentration of agrochemical elements and compounds disintegrate along the furrows on all agrochemical fields except in the case of pH.

Keywords: Agrochemicals; concentration dissipation; runoff and chemical elements.

1. INTRODUCTION

Agrochemicals is defined as any substance used in the management of an agricultural ecosystem; including fertilizers, pH adjusting agents, soil conditioners, pesticides, herbicides and crop-growth regulator [1]. In order to significantly improve agricultural productivity and to meet the ever-increasing food and fibre needs of the world, the use of agrochemicals has increased globally [2]. It has been reported that, the widespread use of agrochemicals in modern irrigation techniques in combination with improved seeds has largely increased agricultural productivity. However, their effects on the environment and agricultural sustainability are of concern. However, their effects on the environment and sustainability of agriculture are of great concern [3]. For instance, Sharma and Singhvi [2] reported that larger percentage of the agrochemical's application affects soil chemical and biological properties. Sebio *et al.* [4] and Singh [5] in their respective studies found out that higher concentration of herbicides decreases the concentration of both micro and macro nutrients in the soil as they have very low degradation effect especially at higher temperature, while medium and lower concentration increases certain chemical elements like N, P, K, Cu, Mn, Zn and Fe in the soil. Bhardwaj and Sharma [6] reported that, in each application of agrochemicals especially pesticide, only about 0.1% of the applied quantity is used by the target while the remaining 99.9%

are left in the environment. Meftaul *et al.* [7] reported that most of these chemical elements left in the soil are either ingested by insects, worms or microorganisms; exported to surface water bodies or leached to groundwater after certain quantities would have evaporated or drift off. According to Geyikci [8] agrochemicals applied on farms, either dissolved or suspended in water, are transported via runoff (surface flow or interflow), and with some of the suspended elements lost to soil particles while in transit. Some of these agrochemical elements after application are transformed into metabolites, most of which are found to be of higher concentration than the original elements [9].

Environmental awareness on the effects of agricultural chemicals in Nigeria and some other parts of Africa is still low, especially in places where agricultural chemicals are used over the years without comprehensive Environmental Impact Assessment (EIA) or programmes. The need for detailed environmental study of such practices so as to have a comprehensive view of the environmental impacts of these chemicals in such countries is germane towards providing detailed and comparative analyses for proper environmental management and sustainability. Although, several studies (Jimoh et al. [3], Guzzella et al. [9], Hotton et al. [10], Geyikci [8], Seibo et al. [4], McKinlay et al. [11], Ogbodo and Onwa [12], Adeoye et al. [13], Bhardwaj and Sharma [6], Singh [5], Biswas et al. [14], Maton

et al. [15], Calda [16], Meftaul et al. [7]revealed that various levels of agrochemical concentrations have been found in air, sand dust, soils, surface and groundwaters, blood, breast milk, semen and urine of farmers, there is dearth of information on the level of dissipation (of such agrochemicals) along their flow paths particularly in Southwestern and North-central Nigeria.

The continuous application of agrochemicals over the years has been a thing of admiration due to the remarkable increase in yield associated with it. Though, recently researches have highlighted some negative effects of agrochemicals application on the soil, water, animal and fish, including man as the final consumer [5,4,17]. Toxic chemical elements resulting from agricultural chemicals applied on soil to boost crop yield are subsequently transferred from plant that absorb them into animals that feed on the plant, including human beings. This process of chemical element transfer through food chain has resulted in terminal illness such as cancer, kidney and liver failure [9,18,17]. However, the rate at which these chemicals move from the point of application to other places (surface and groundwater) had not been fully studied. This research determines the concentration of applied agrochemicals along their pathways from the point of application.

2. MATERIALS AND METHODS

2.1 The Study Area

The study was carried out at the National Centre for Agricultural Mechanization (NCAM) farm. The farm was established within the premises of National Centre for Agricultural Mechanization (NCAM) headquarters Idofian, in 1978 with a land area of 1000 ha. NCAM is about 20 km from Ilorin metropolis along Ilorin – Omuaran road. It is situated on Longitude $4°39´$ E and Latitude $8°23´$ N. Fig. 1 shows the location map of the study area. The altitude of the study area

is 369 m above sea level. The soil in the area is predominantly sandy loam. The area is drained by an annual stream named Odo-omu (Fig. 2). The climate is generally influenced by the Inter-Tropical Convergence Zone (ITCZ) which results in wet and dry seasons. The wet season usually starts in April and lasts till late October, with the peak rainfall occurring between June and September while the dry season lasts between November to March. The mean annual rainfall of the area is 1700 mm while the mean monthly maximum and minimum temperatures within the area are $31℃$ and $29℃$, respectively. Highest temperatures are usually recorded in the months of February, March and April, and the potential evapotranspiration of the area is between $1500 – 1700$ mm per annum [19].

2.2 Description of the Experimental Field

An undulating field was developed to assume a natural farmland conditions with a height difference of 2, 1, 0.5 and 0.25 m in a rectangular box of 20 m length and 4 m breadth (Fig. 3). The experimental field was developed in four forms of equal measurements, with four furrows on each, running along the length of the four fields. The furrows are divided at 1 m interval along the 20 m length, taking their reference points from a rectangular block of 20 m length.

2.3 Experimental Procedure and Sample Collection

One gram (1 g) each of NPK (15:15:15) and urea fertilizers, 3 ml each of herbicide (glyphosate) and pesticide (organochlorine) were mixed with 1000 ml of water to form solution based on the manufacturer's specification as itemized in Table 1. Two hundred millilitre (200 ml) of each prepared agrochemical was applied on the field. Shower head was used to simulate rainfall at the rate of 2 mm/h into the furrows to imitate runoff from actual rainfall.

Table 1. Agrochemical samples preparation

S/N	Types of Agrochemicals	Quantity of Agrochemical	Quantity of Solute (H_2O) (ml)	Sample size Applied (ml)
1	NPK	1 g	1,000	200
2	Urea	1 g	1,000	200
3	Herbicide (Glyphosate)	3 ml	1,000	200
4	Pesticide (Organochlorine)	3 ml	1,000	200

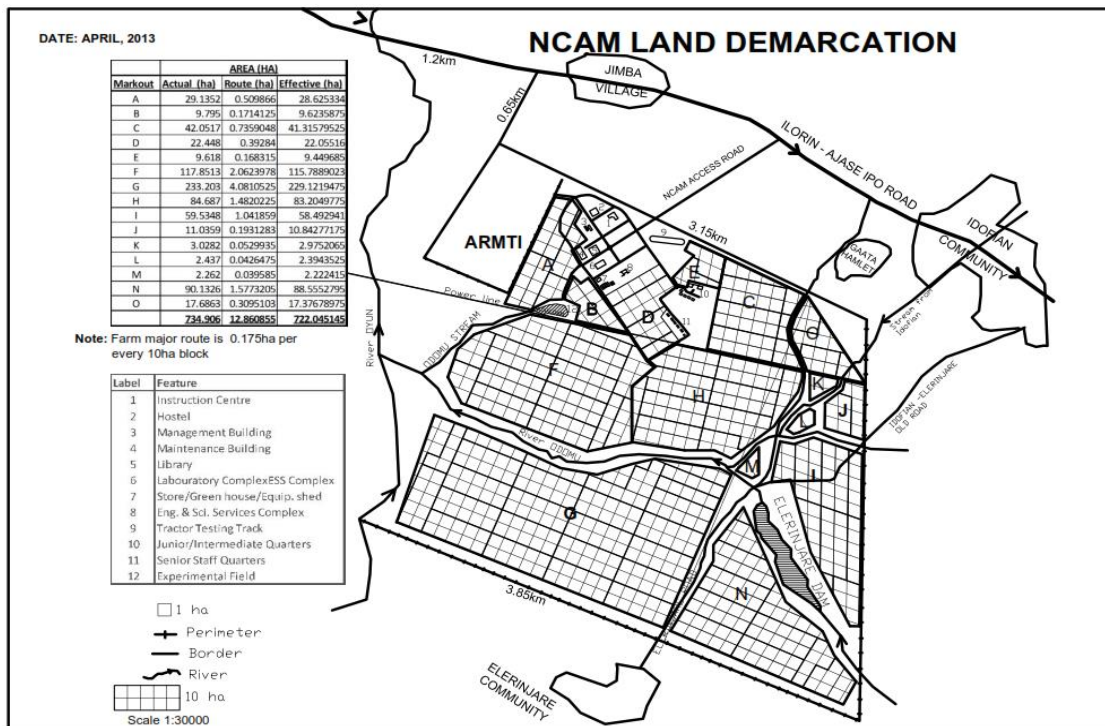**Fig. 1. Location map of the study area**

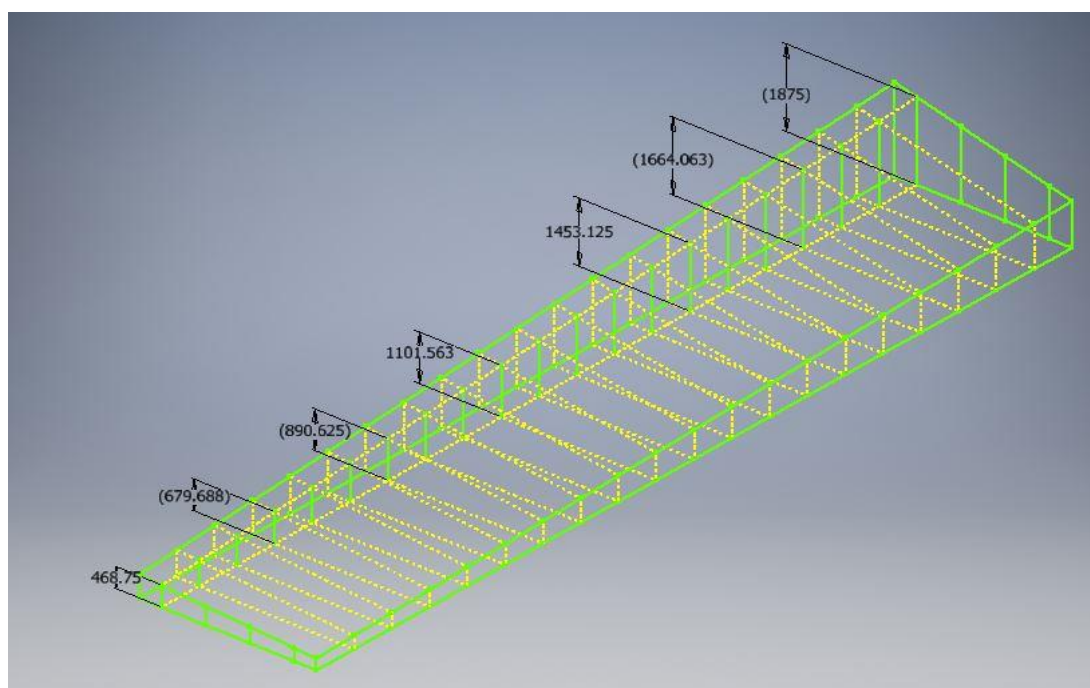**Fig. 2. Area and land demarcation of the study area**

Fig. 3. Model of runoff experimental field showing height difference (mm)

Runoff samples were collected at 1 m interval along the 20 m furrow and at different heights of the furrows on the four experimental fields. The collected samples were filtered using 0.45 μm filter paper (Whatman Grade 602 h) to remove physical contaminants (papers, debris, twigs silts, etc.) and the filtrate were placed in a well labelled plastic bottle in preparation for lab analysis. Soil samples were randomly collected at eight different points across the four-furrow height and distances on all the fields. Same samples of the soil were air-dried at between $20 - 25\text{℃}$ and at relative humidity of between 20 and 60% according to Jackson [20] for three days. After drying, the soil was milled and sieved using 2 mm standard mesh. The sieved soil samples were bagged for analysis.

2.4 Analysis of Soil and Runoff Samples

The nitrate nitrogen (NO_3^--N) contents in the runoff and soil samples were determined by ion chromatography (HJ 84- 2016) method as described by Li *et al.* [21]. Colorimetric methods were used to determine Potassium (K^+) using Pallintest photometer 7100 according to APHA [22] as described by Adebayo et al. [23].

Atomic Absorption Spectrophotometer (AAS) was used to determine the concentrations of the Mn^{2+}, Ca^{2+} Mg^{2+}, and Na^+ in the runoff samples. A calibration of the AAS machine was done for each element to be determined using separate standards prepared with different cathode lamp for each element and corresponding wavelength are introduced to the AAS as described in APHA [22]. The concentration of each element was calculated using Equation 1.

Metal (mg L^{-1}) = Gradient of slope × absorbance × 100 × δ / 10   (1)

Where:

   δ = dilution factor

In the case of soil samples, 10 g of soil samples were weighed into a conical flask, and 100 ml of 1M ammonium acetate and 0.1M HCl was added for digestion [20]. The mixture is stirred on mechanical shaker for 1 h and then filtered. The filtrate was analysed using AAS as explained above. The pH and electrical conductivity (EC) were measured *in situ*. pH was measured with pH meter (PHS-3c) while TDS and EC with a multi-parameter Analyzer (DZS- 706).

3. RESULTS AND DISCUSSION

The results of the changes in concentrations of the NPK, Urea, glyphosate and organochlorine inrunoff and soil samples along the furrow (definite parts) are discussed in the following sections.

3.1 Chemical Elements in Runoff and Soil from NPK Fertilizer Applied Field

The concentrations of the chemical elements as they move along the furrow on NPK fertilizer applied field are presented in Fig 4a-e and Fig 5a-e for runoff and soil, respectively. From the Figures, concentrations of chemical elements for the runoff demonstrate an inverse relationship with distance from point of application except for pH which increased as the solution move along the furrow. The maximum and minimum values of electrical conductivity- 174.51 & 95.75 µS/cm, pH- 7.54 & 5.72, nitrogen- 0.68 &

0.21%, phosphorus- 0.36 & 0.09%, manganese- 0.47 & 0.1 mg L^{-1}, zinc- 0.66 & 0.25 mg L^{-1}, magnesium-7.88 & 4.63 mg L^{-1} and potassium- 16.15 & 7.28 mg L^{-1} were obtained in the constituents, respectively from the runoff samples of NPK fertilizer applied field. The corresponding values in the soil sample are electrical conductivity- 125.59 & 110.23 µS/cm, pH- 7.31 & 6.09, nitrogen- 0.749 & 0.22%, Phosphorus- 0.53 & 0.12%, manganese- 0.55 & 0.11 mg L^{-1}, zinc- 0.85 & 0.32 mg L^{-1}, magnesium- 8.16 & 4.79 mg L^{-1} and potassium- 17.0 & 8.35 mg L^{-1}, respectively.
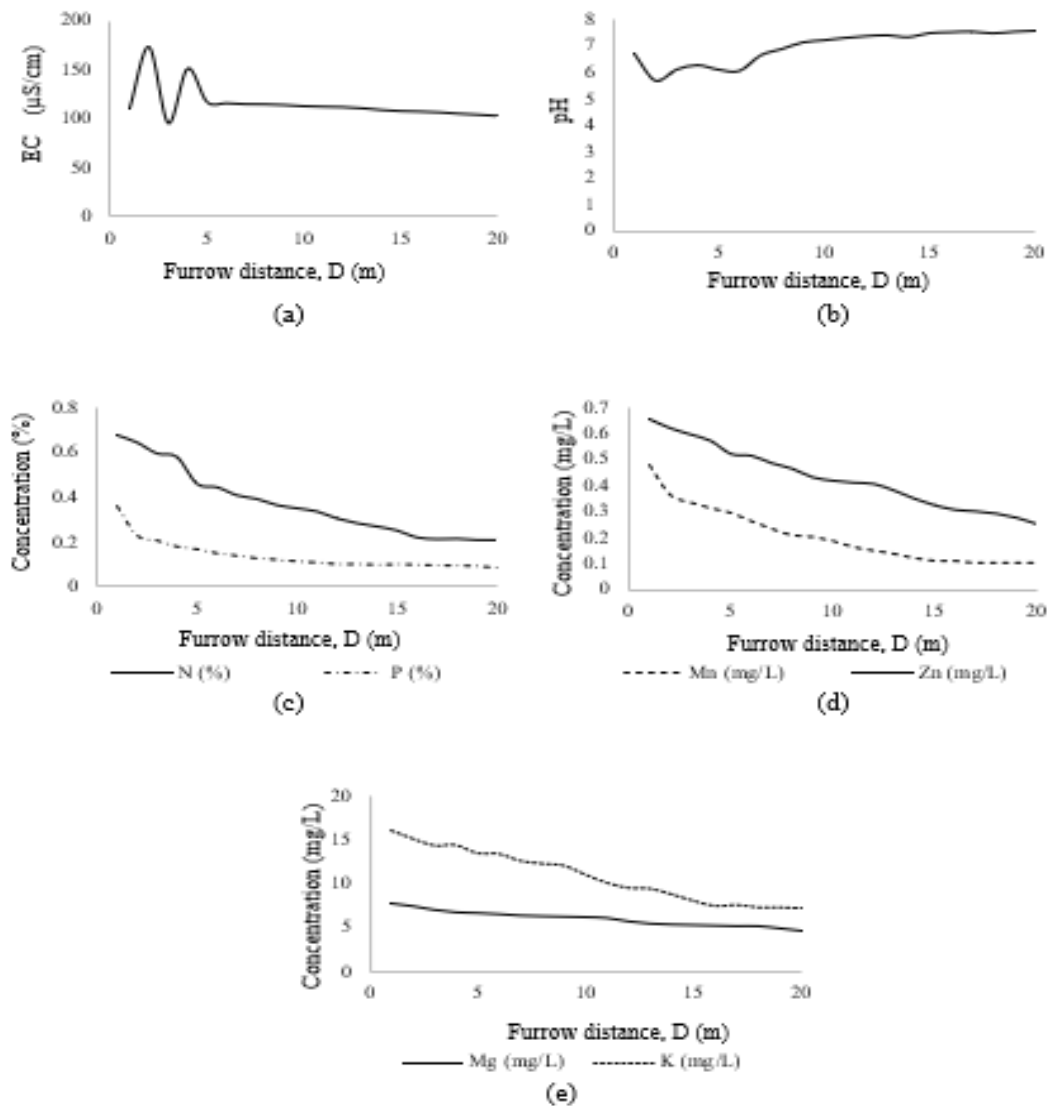

Fig. 4. Change in concentration of agrochemicals in from runoff on NPK fertilizer field: (a) electrical conductivity (b) pH (c) nitrogen and phosphorus (d) manganese and zinc (e) magnesium and potassium
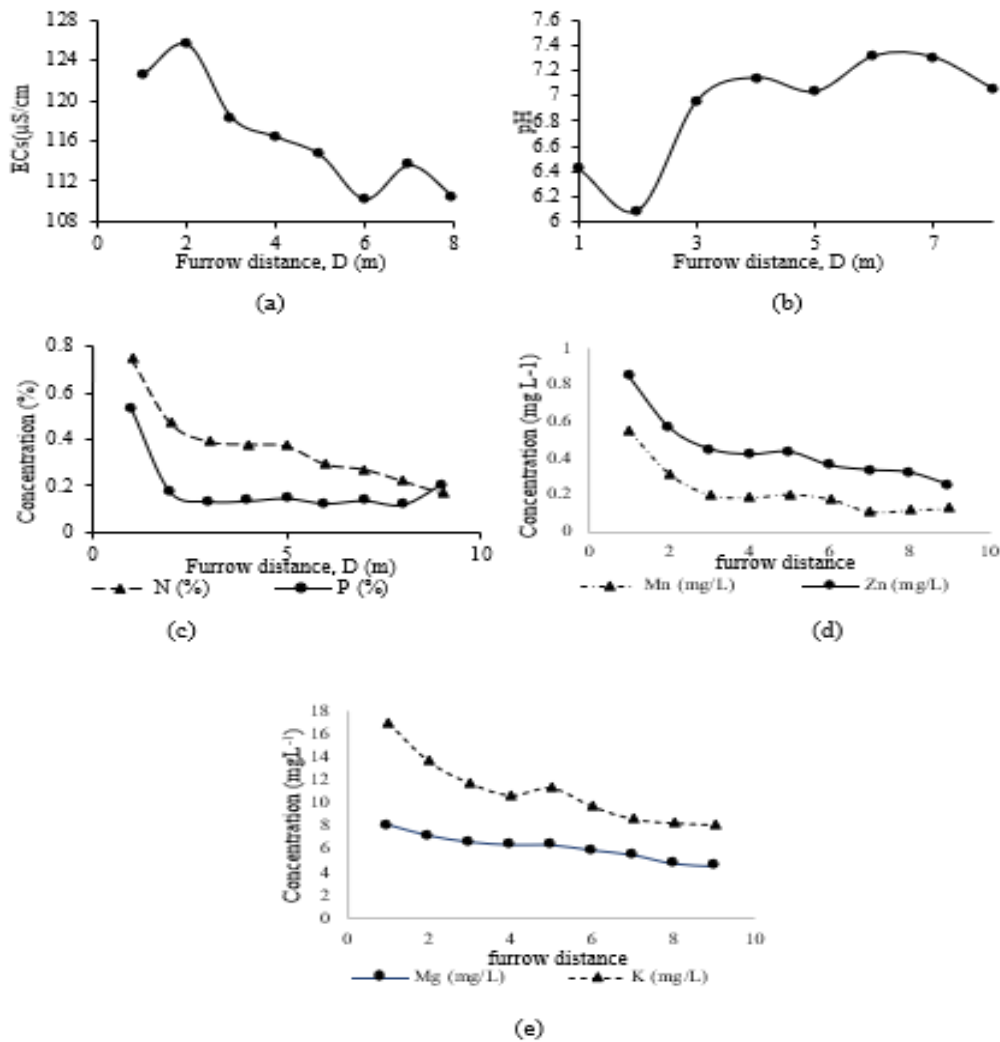
Fig. 5. Change in concentration of agrochemicals in soil on NPK fertilizer field: (a) electrical conductivity (b) pH (c) nitrogen and phosphorus (d) manganese and zinc (e) magnesium and potassium

The maximum values of chemical elements in the runoff samples were obtained at the application point except in the cases of electrical conductivity and pH, this could be due to the influence of the initial EC of the soil as stated by Shi *et al.* [24]. The maximum value of electrical conductivity was recorded at a furrow distance of 2 m with a difference of 65.5 µS/cm from the value obtained at the point of application. The high value of EC may be related to the previous agricultural activities or the texture of the soil between the point of application and 18 m furrow distance which tends to retain more chemical from the applied water [25]. The values of pH obtained were found to increase as the distance from the point of application (of the chemicals) increases along the furrow, this could be attributed to the initial soil pH [26] and organic matter contents of the soil as corroborated from the findings of Chen et al. [27]. The highest value recorded for pH was at 20 m furrow distance with a difference of 1.493 compared with the value at the point of application. This variation may be as a result of the presence of other chemicals in the sample area which may have caused other chemical reactions, thereby increasing the pH in the runoff at the point [28].

Tables 2a and b present the summary of relationships between the concentrations of the agrochemical elements and compounds and the furrow distance for the runoff and soil, respectively on the NPK field. The R^2 values from the table provide information on the extent of influence the furrow distance has on the changes in concentration of the agrochemicals.

From the table, it is shown that furrow distance account less (for about 26.3%) of the variation in ECC concentration in runoff from NPK fertilizer field, suggesting that other factors such as residual soil chemical elements and compounds not considered in this study may have greater influence on the variation of ECC concentration than the furrow distance. In contrast, while variation in the concentration of P is moderately (65.3%) influenced by the furrow distance, the variation in concentration of Zn is largely (98.14%) influenced by furrow distance. In Table 2b on the other hand, furrow distance can account for about 82.5% of the variation in concentration of ECC in the soil of NPK fertilizer field while only 26.2% of the variation in the concentration of P could be explained by furrow distance.

Table 2a. Summary of the relationship between concentration and furrow distance in NPK (15:15:15) field runoff

Elements	Trend equations	R^2
ECC	ECC = -1.5263D + 131.38	0.263
pH	pH = 0.0884D + 6.03	0.776
N	N = = -0.025D + 0.6328	0.922
P	P = -0.0089D + 0.2365	0.653
Mn	Mn = -0.0168D + 0.3806	0.877
Zn	Zn = -0.0203D + 0.644	0.981
Mg	Mg = -0.1493D+7.6334	0.966
K	K = -0.4977D+16.162	0.976

D means the furrow distance, m

Table 2b. Summary of the relationship between concentration and furrow distance in NPK field soil

Elements	Trend equations	R^2
ECC	ECC = -2.036D+125.630	0.825
pH	pH = 0.136D+6.300	0.589
N	N = -0.057D+0.652	0.827
P	P = -0.025D+0.312	0.262
Mn	Mn = -0.041D+0.428	0.668
Zn	Zn = -0.057D+0.727	0.778
Mg	Mg = -0.407D+8.230	0.958
K	K = -0.971D+15.926	0.864

D means the furrow distance, m

3.2 Chemical Elements in Runoff and Soil from Urea Fertilizer Applied Field

The concentrations of chemical elements in runoff and soil from urea fertilizer field as they move along the furrow are presented in Fig.6(a-e) and Fig.7(a-e), respectively. The maximum and minimum values of EC, pH, nitrogen, phosphorus, manganese, zinc,

magnesium and potassium are 186.33 &176.25 µS/cm, 7.64 & 7.14, 0.48 & 0.21%, 0.38 & 0.21%, 0.65 & 0.41 mg L^{-1}, 0.49 & 0.23 mg L^{-1}, 7.64 & 5.48 mg L^{-1}and 10.46 & 8.23 mg L^{-1}, respectively. The corresponding values of EC, pH, nitrogen, phosphorus, manganese, zinc, magnesium and potassium for soil samples are 197.18 & 183.68 µS/cm, 7.39 & 6.99, 0.51 & 0.40%, 0.50 & 0.36%, 0.85 & 0.55 mg L^{-1}, 0.58 & 0.41 mg L^{-1}, 9.82 & 7.21 mg L^{-1}and 13.75 & 11.3 mg L^{-1}, respectively.

Tables 3a and b present the summary of relationships between the concentrations of the agrochemical elements and compounds and the furrow distance for the runoff and soil respectively on the Urea fertilizer applied field. From Table 3a, furrow distance account more for about 93% of variations in EC concentration but for only about 21% variation in pH. Other chemicals were moderately accounted for by furrow distance. However, in Table 3b furrow distance accounted for about 85.5% of the variation in concentration of Mn in the soil of Urea fertilizer applied field while as much as 45.4% of the variations in the concentration of pH could be explained by furrow distance.

Table 3a. Summary of the relationship between concentration and furrow distance in urea field runoff

Elements	Trend equations	R^2
EC	ECC = -0.5643D+188.21	0.933
pH	pH = 0.0131D+7.2738	0.2096
N	N = -0.0103D+0.4384	0.7731
P	P = -0.0068D+0.3635	0.5296
Mn	Mn = -0.0092D+0.5754	0.5427
Zn	Zn = -0.0116D+0.4718	0.8531
Mg	Mg = -0.0619D+7.2452	0.5143
K	K = -0.0803D+9.9885	0.5006

D means the furrow distance, m

Table 3b. Summary of the relationship between concentration and furrow distance in urea field soil

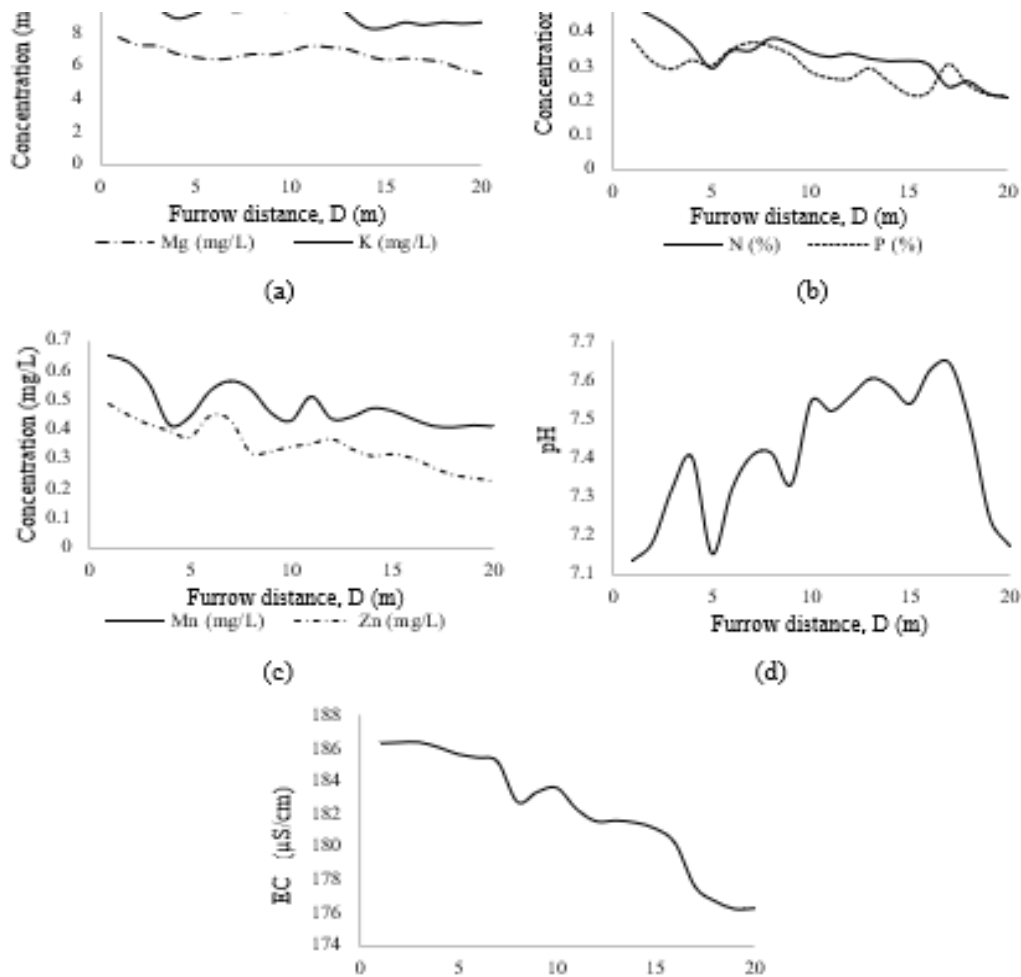| Elements	Trend equations	R^2
EC	ECC=-2.290D+198.510	0.579
pH	pH= 0.047D+6.996	0.454
N	N= -0.027D+0.550	0.623
P	P= -0.030D+0.557	0.823
Mn	Mn= -0.059D+0.933	0.858
Zn	Zn= -0.037D+0.650	0.769
Mg	Mg= -0.488D+10.743	0.757
K	K= -0.603D+14.913	0.728

D means the furrow distance, m

Fig. 6. Change in concentration of agrochemicals on urea fertilizer field runoff; (a) electrical conductivity (b) pH (c) nitrogen and phosphorus (d) manganese and zinc (e) magnesium and potassium

3.3 Chemical Elements in Runoff and Soil from Glyphosate Applied Field

The respective variation in concentrations of chemical elements in runoff and soil as they move away from the point of application on the herbicide field are depicted in Fig. 8 (a - e) and 9 (a - e), respectively. On the average, the maximum and minimum values were recorded for electrical conductivity, pH, nitrogen, glyphosate, manganese, zinc, and magnesium as 285.78 & 114.00 µS/cm, 7.82 & 6.49, 0.67 & 0.13 mg/kg, 0.09 & 0.03%, 1.60 & 0.41 mg L^{-1}, 2.59 & 0.45 mg L^{-1} and 12.76 & 8.35 mg L^{-1} were recorded for electrical conductivity, pH, nitrogen, glyphosate, manganese, zinc, and magnesium, respectively. The corresponding values of electrical conductivity, pH, nitrogen, glyphosate, manganese, zinc, and magnesium for soil samples were 306.41 & 250.11 µS/cm, 7.69 &

6.36, 0.52 & 0.26 mg/kg, 0.19 & 0.09%, 1.52 and 0.62 mg L^{-1}, 2.88 & 1.25 mg L^{-1} and 15.19 & 9.70 mg L^{-1}.

Tables 4a and b present the summary of relationships between the concentrations of the agrochemical elements and compounds and the furrow distance for the runoff and soil respectively on the herbicide field. Table 4a shows that pH and EC are significantly influenced by furrow distance accounting for 96% and 94% of variation in pH and EC, respectively. However, distance along the furrow accounted for only 56% and 39% of glyphosate and N concentrations, respectively. On the other hand, furrow distance moderately influenced the concentrations of Mn and Zn, accounting for 81% and 74%, respectively. Table 4b shows that furrow distance account for about 94.9 and 91.8% of the variation in the concentrations of N

and pH, respectively in the soil of urea fertilizer applied field while 64.4% of the variation in the concentration of ECC could be accounted for by furrow distance.

Table 4a. Summary of the relationship between concentration and furrow distance (D) in herbicide (glyphosate) field runoff

Elements	Trend equations	R^2
ECC	ECC = -9,4122D+303.9260	0.9459
pH	pH= 0.06677D+6.5802	0.9624
N	N= -0.0136D+0.358	0.3988
Mn	Mn= -0.0535D+1.35080	0.8165
Zn	Zn= -0.0813D+1.8795	0.7445
Mg	Mg= -0.1107D+10.725	0.3772
Gly	Gly= -0.0023D+0.0821	0.5561

Gly = Glyphosate, D = Furrow distance, m

3.4 Chemical Elements in Runoff and Soil from Organochlorine Field

The variations in the concentration of the chemical elements as they move away from the point of application along the furrow on the organochloride field are presented in Fig. 10 (a – e) and 11 (a – e). The maximum and minimum values obtained for electrical conductivity, pH, nitrogen, organochlorine, manganese, zinc and magnesium in the runoff were 380.48 & 344.37 µS/cm, 7.86 & 6.66, 0.56 & 0.30 mg/kg, 0.18 & 0.05 %, 0.91 & 0.68 mg L^{-1}, 1.45 & 0.81 mg L^{-1} and 14.68 & 12.48 mg L^{-1}, respectively. The corresponding values obtained in soil samples are 392.76 & 356.27 µS/cm, 7.58 & 6.47, 0.62 & 0.36 mg/kg, 0.40 & 0.31%, 1.17 & 0.87 mg L^{-1}, 1.57 & 0.95 mg L^{-1}.
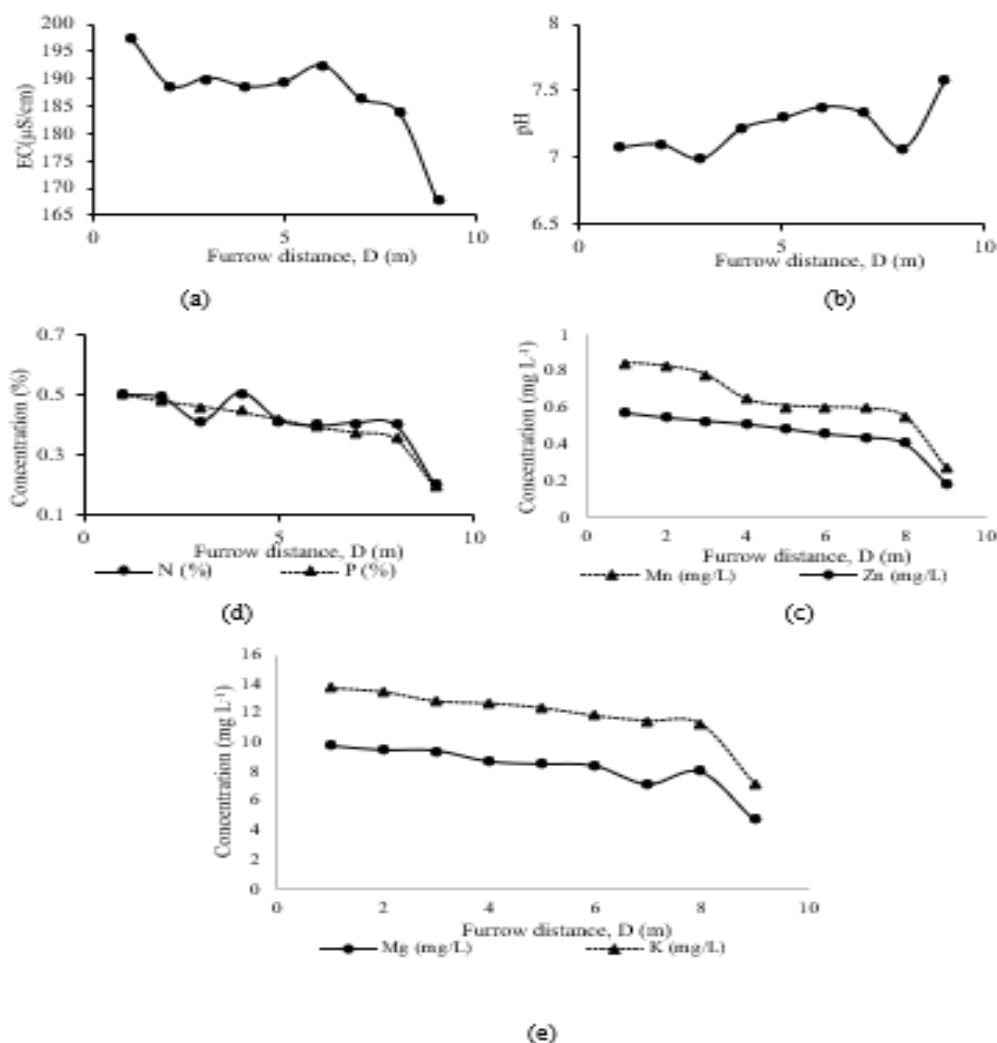

(a)

(b)

(d)

(c)

(e)

Fig. 7. Change in concentration of agrochemicals in soil of urea fertilizer field: (a) electrical conductivity (b) pH (c) nitrogen and phosphorus (d) manganese and zinc (e) magnesium and potassium
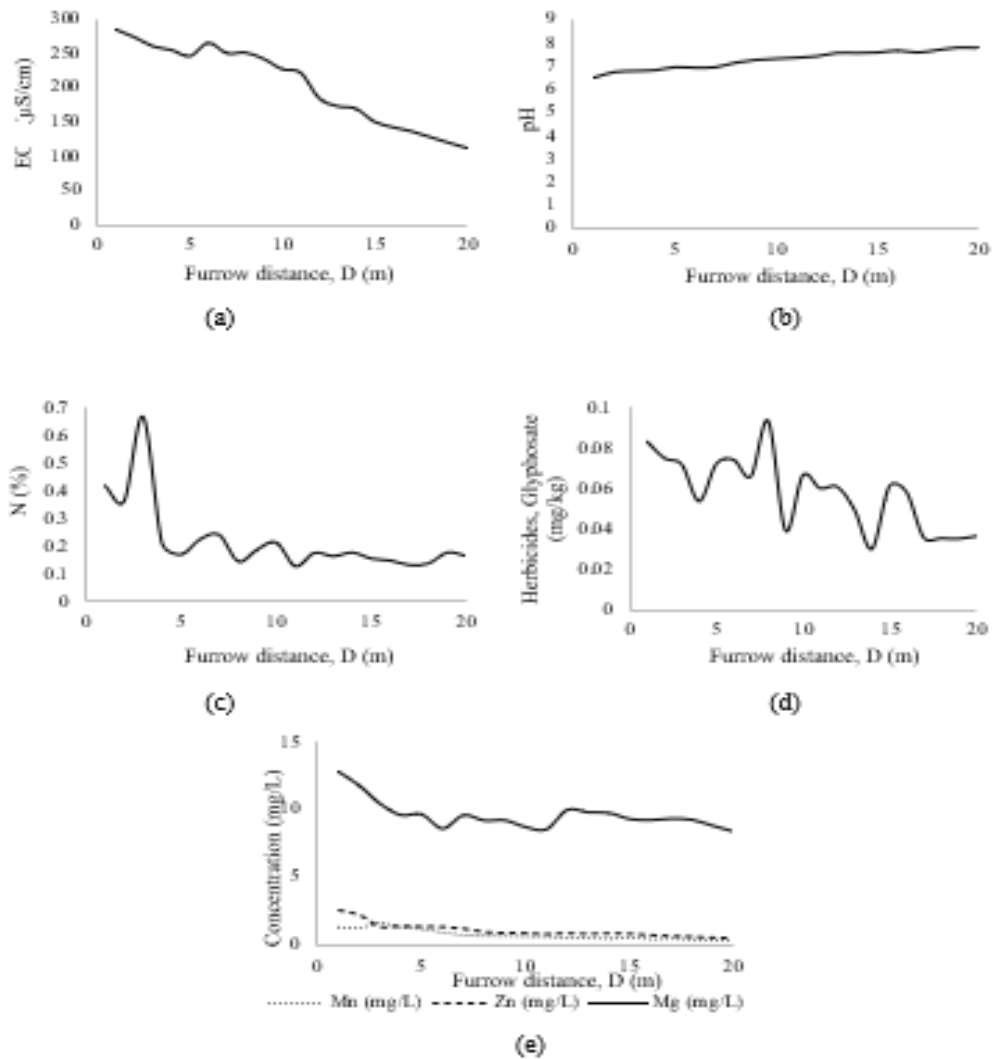
Fig. 8. Change in concentration of agrochemicals on *glyphosate* field runoff; (a) electrical conductivity (b) pH (c) nitrogen (d) Glyphosate (e) manganese, zinc and magnesium

Table 4b. Summary of the relationship between concentration and furrow distance (D) in herbicide (glyphosate) field soil

Elements	Trend equations	R^2
ECC	ECC = -5.450D+300.060	0.644
pH	pH= 0.0223D+6.016	0.918
N	N= -0.043D+0.572	0.949
Mn	Mn= -0.127D+1.520	0.887
Zn	Zn= -0.243D+3.125	0.924
Mg	Mg= -0.905D+16.040	0.887
Gly	Gly= -0.012D+0.201	0.892

Gly = Glyphosate, D = Furrow distance, m

The summary of relationships presented in Tables 5a and b revealed that concentration of different parameters measured in the runoff varied significantly with the furrow distance. Furthermore, furrow distance account for only about 55% of the EC concentration and can explain as much as 95% of the variation in the concentration of the Mn (Table 5a). In contrast, only about 0.1% of the variation in the concentration of organochloride in the soil is accounted for by furrow distance and a high 96% of the variation in Mg concentration (Table 5b) this suggested that other factors (such as soil physical and chemical properties as well as chemical reactions) that were not considered in this study has influence on the variation of the concentration of the agrochemicals along the furrow [29-30].
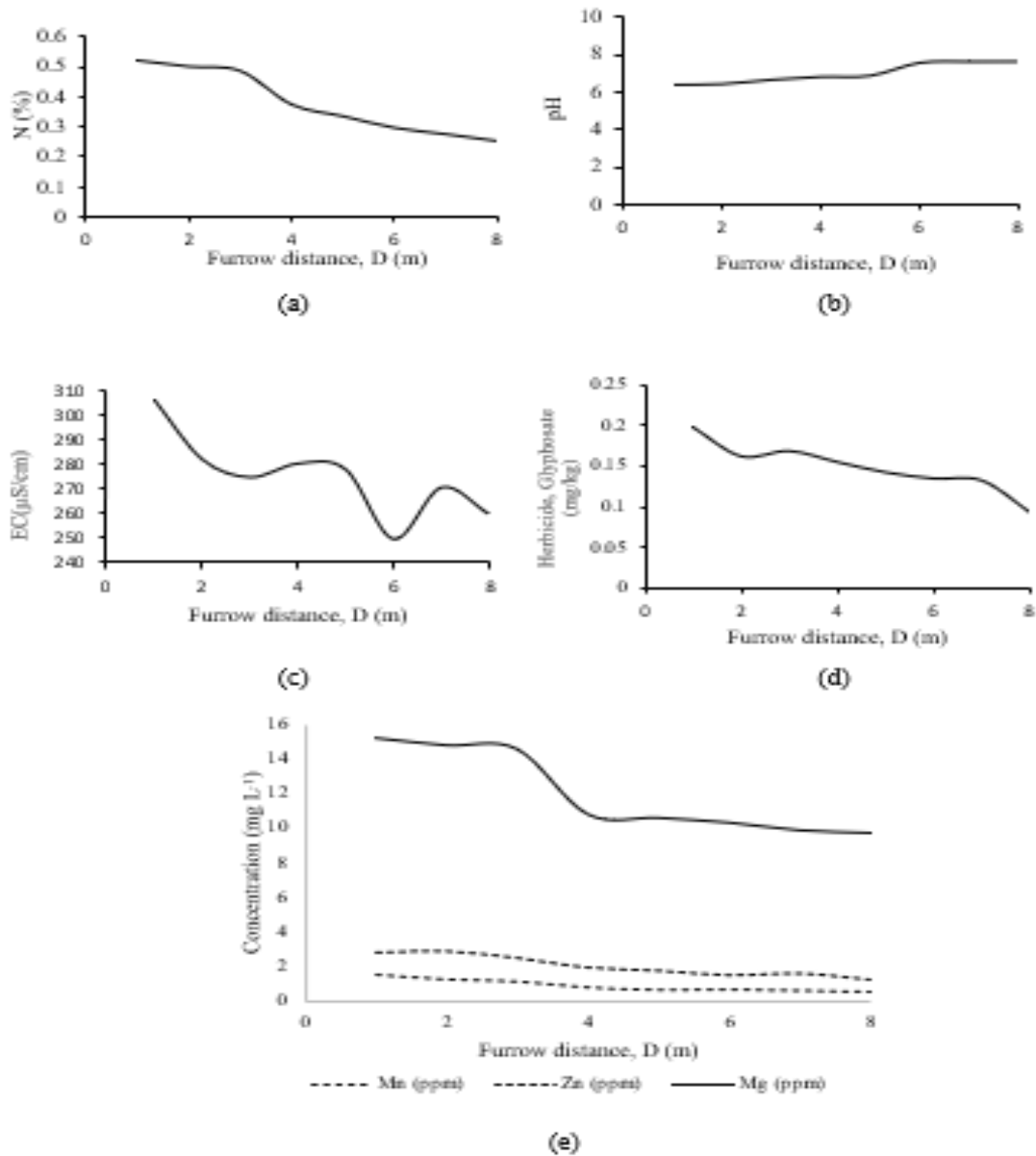
Fig. 9. Change in concentration of agrochemicals on *glyphosate* field soil; (a) nitrogen (b) pH (c) electrical conductivity (d) Glyphosate (e) manganese, zinc and magnesium

Table 5a. Summary of the relationship between concentration and furrow distance (D) in pesticide (organochlorine) field runoff

Elements	Trend equations	R^2
ECC	ECC = -1.3936D+375.23	0.5506
pH	pH= 0.0671D+6.6723	0.9285
N	N= -0.0092D+0.4703	0.5446
Mn	Mn= -0.0355D+1.4711	0.9523
Zn	Zn= -0.0006D+0.8153	0.0035
Mg	Mg= -0.1005D+14.754	0.8711
OC	OC= -0.0066D+0.1955	0.7858

OC = Organochlorine, D = Furrow distance, m

Table 5b. Summary of the relationship between concentration and furrow distance (D) in organochloride field soil

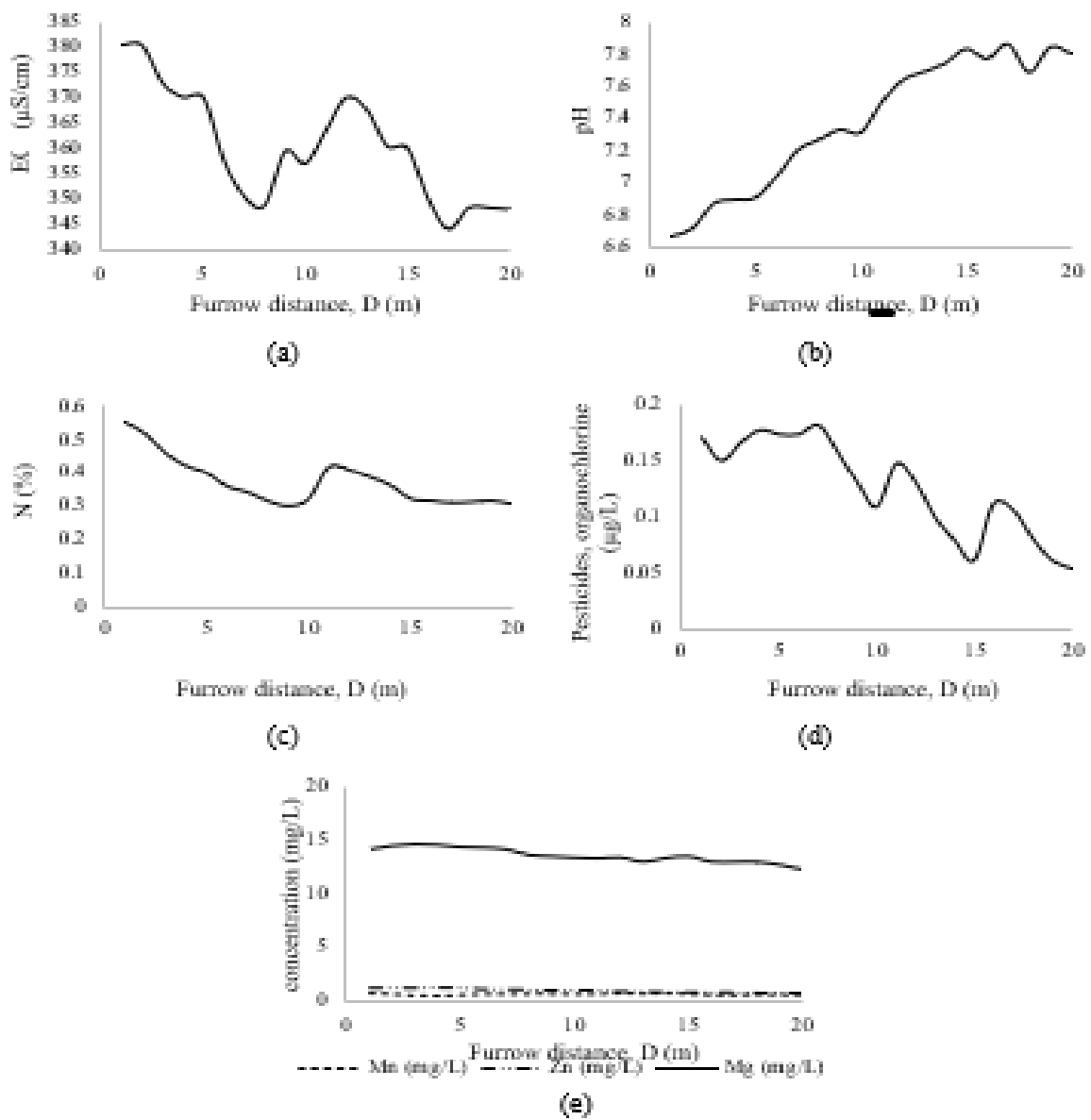| Elements	Trend equations	R^2
ECC	ECC = -4.630D+394.070	0.858
pH	pH= 0.169D+6.299	0.954
N	N= -0.032D+0.584	0.726
Mn	Mn= -0.088D+1.654	0.956
Zn	Zn= -0.033D+1.101	0.695
Mg	Mg= -0.216D+15.328	0.963
OC	OC= -0.001 D+0.355	0.001

OC = Organochlorine, D = Furrow distance, m

Fig. 10. Change in concentration of agrochemicals on organochloride field runoff; (a) electrical conductivity (b) pH (c) nitrogen (d) organochlorine (e) manganese, zinc and magnesium
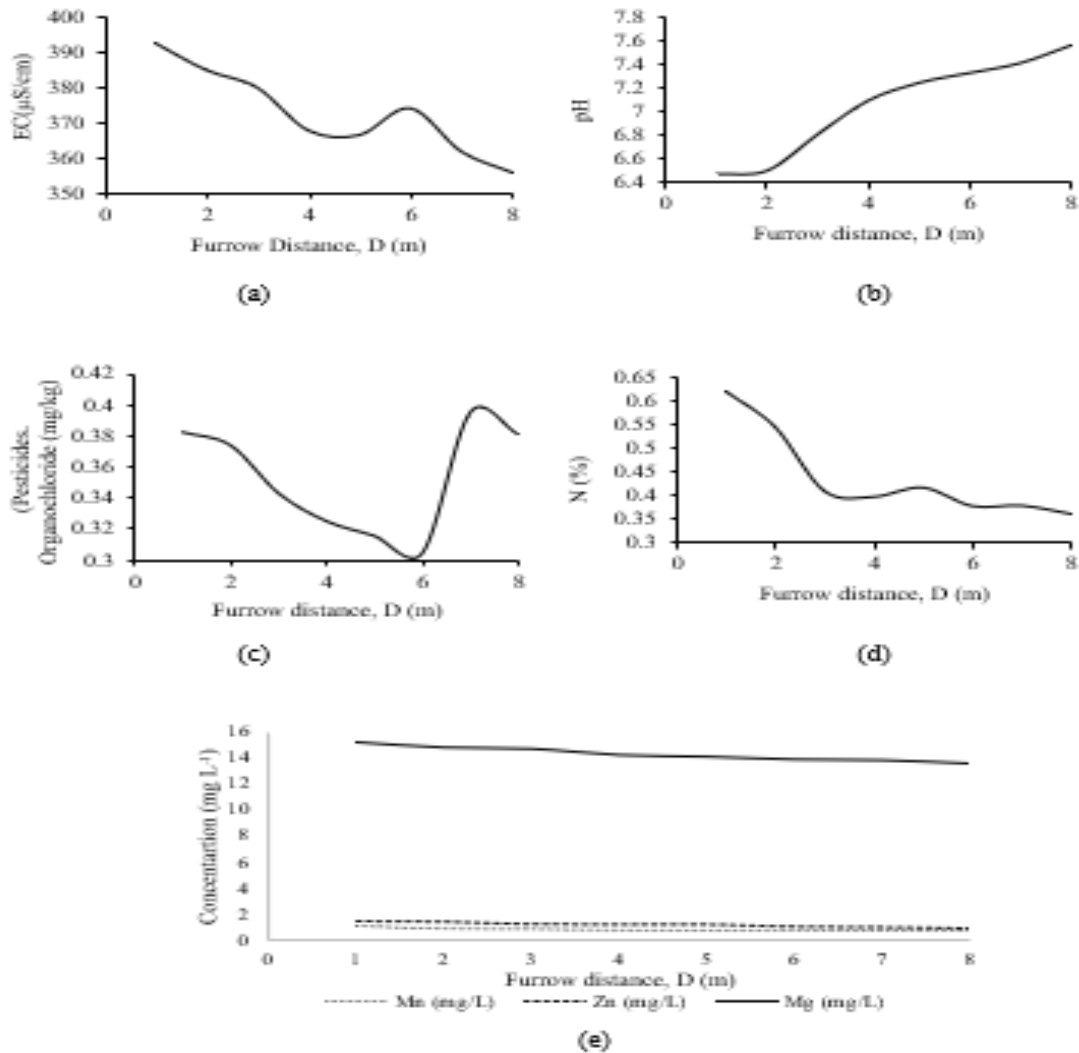
Fig. 11. Change in concentration of agrochemicals on organochloride field soil; (a) electrical conductivity (b) pH (c) nitrogen (d) organochlorine (e) manganese, zinc and magnesium

4. CONCLUSIONS

The concentration of chemical elements and compounds in the runoff and soil samples are found to reduce at varying rates along the furrow runs in all the experimental fields. While some parameters in the agrochemical degenerated continuously with furrow distance, some fluctuated, possibly due to soil properties. The soil contains higher values of agrochemical concentrations than the runoff due to adhesion of chemical constituent in the soil pores. The research has given an insight on the movement, concentration level and extent of coverage of the excess chemical elements in surface water with respect to the point of application. Hence, a decision support system could be developed to guide in the admiration of applied agrochemical in the study area and soil of similar characteristics.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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