Original Article

Physio-chemical studies of some irrigation water sources from Ogbia, Bayelsa state and their effects on elemental composition of *Zea mays* L.

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Abstract

The physico-chemical characteristics of four different water sources and their effects on the elemental composition of *Zea mays* L. were evaluated in the laboratory for two (2) weeks. Standard procedures were used to determine the physico-chemical characteristics (pH, salinity, conductivity, turbidity, TDS, TSS, COD, BOD, DO, Mg, Ca, Na, K, Pb etc) of the water samples. Seedlings of the test crop were raised and irrigated with varied sources of water samples alongside a control treatment (distilled water). Mineral nutrient composition of the plant (Pb, Cd, Cr, Ca, Mg, Na, K, NO_3^-, PO_4, Fe, Cu, Zn, and Mn), were estimated. The results showed that there were marked differences ($P < 0.05$) in the physico-chemical characteristics of the four water samples. The highest content of potassium, sodium and phosphate were recorded in decreasing order from stream, tap, rain and distilled water, while, the Mg, and Mn contents in the test crop were in the decreasing order from stream, rain, tap and distilled water. In addition, there were significant differences ($P < 0.05$) in the content of Ca among the four water sources, with values higher than that of the control. This study suggests that there is need for appropriate environmental pollution control measures, in order to keep some water parameters within optimum range for proper metabolism in the test crop in the study area.
Keywords: Physio-chemical, water sources, Ogbia, effects, elemental composition, Zea mays L.

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INTRODUCTION

Water is one of the important constituents in the cell in view of its roles in influencing morphological, anatomical and physiological processes[8,21]. Plants utilize soil water for metabolic processes in the cell[4]. Water provides the medium for absorption of minerals and organic matter, and activates various enzymes and metabolic activities in the living cell[14]. Polluted water has been shown to have threatening consequences on plants, with its specific effects varying depending on the type or nature of the pollutants[5]. There are prevalent situations in the use of contaminated water for irrigation purposes[3]. Plants roots absorb pollutants from aquatic or terrestrial media, which may lead to phytotoxicity due to bioaccumulation of these pollutants in plant tissues[11]. Some of the symptoms of phytotoxicity in plants include poor growth, death spots on the leaves, and even death of the entire plant[6,20]. The test crop *Zea mays* (Poaceae) is cultivated as one of the stable food and economic crops in farmlands in Bayelsa State, Nigeria. It is used as a stable food crop and constitutes a major constituents to many important dishes, as well as a basal medium and raw material for industries [20]. Water pollution is one of the serious problems in the Niger Delta region of Nigeria, in view of the prevailing cases of petroleum oil pollution in the area. Similarly, the characteristic water terrain of Bayelsa State with its attendant's problem of flooding alongside agro-chemical and sewage pollution justifies the increasing need for this

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study. Although, series of works have been carried out on water pollution and its effects on plants, this present study was carried out to evaluate the elemental components of *Zea mays* L. during early seedling growth in medium treated with different sources of water from Ogbia, Bayelsa State, Nigeria.

MATERIALS AND METHODS

Collection and Analysis of Water samples

The three sources of water (stream, tap, and rain water) used for this study were obtained from Otuoke, while the distilled water was obtained from Laboratory shop, in Yenagoa, Bayelsa State, Nigeria. Standard methods were used to assess the physico-chemical properties of the water samples[1].

Germination Studies

Seeds of *Zea mays* were collected from certified dealers in Yenagoa, Bayelsa State, Nigeria. Healthy seeds were surface sterilized with distilled water. Ten (10) seeds of the test crop were sown in sterilized Petri-dishes containing two sterile Whatmann's filter paper per treatment. Each level of treatment was replicated five (5) times. The Experimental set up was maintained in a growth chamber under light condition (28 ±1^{o}C) for two (2) weeks

Determination of Mineral Nutrient Composition

Plant materials were harvested, rinsed with distilled water and dried. Pestle and mortar was used to grind the dried plant materials of each sample into powder form. A 0.002mm wire mesh was used to sieve the powder to obtain fine powdered form. Each sample of the fine powdered plant material was kept in small bottles for analysis. The following mineral elements (magnesium, calcium, sodium, potassium, zinc, iron, manganese, chromium, cadmium, lead and copper) were determined using standard methods[1,9].

Statistical Analysis

Analysis of variance (ANOVA) was used to analyse the data generated from the study. Differences in the means were tested using Least Significant Differences (LSD) at probability level of 5%[15].

RESULTS

The results of the water sample analysis showed that average values of pH in samples A, B, C and D ranged from 6.60, 5.75, 5.83, and 6.20, respectively (Table1). Higher values of soluble cations such as Na^{+}, K^{+}, $Ca^{2+}$and Mg^{2+} were recorded in samples B, C and D relative to the control (sample A). Similarly, high concentrations of soluble anions such as Cl^{-}, SO_4^{2-}, HCO_3^{-}, PO_4^{-} and NO_3^{-} were indicated in samples B, C and D comparable to sample A (control) respectively, with sample D having the lowest value. (Table1). The trace elements such as Fe^{3+}, Mn^{2+} and Zn^{2+} recorded high concentrations in samples B, C and D, relative to sample A (control) (Table 1). DO in the water samples had values of 3.02, 6.56, 6.77, and 5.88 mg/l in samples A, B, C, and D, respectively. Values for BOD ranged from 5.07, 19.70, 20.30 to 11.76 mg/l in samples A, B, C, and D, respectively. COD ranged from 12. 08, 39.40, 41.62 to 23.56 mg/l in samples A, B, C, and D, respectively (Table 1). Lower values of lead, cadmium and chromium were recorded in plant materials irrigated with samples A, B, C, and D (Table 2). Contents of iron, zinc and manganese were higher in plant materials irrigated with sample B, C, and D relative to the control (sample A) (Table 2). The content of copper was higher in plant materials treated with sample C and D than the control (sample A), while it was unaffected in sample B comparable to sample A (Table 2). Calcium content in *Z. mays* ranged from 1.22, 7.86, 8.88 to 6.15 mg/g in treatment with sample A, B, C, and D, respectively (Table 2). Magnesium content in the test crop ranged from 0.95, 3.32, 2.48 to 2.78 mg/g in treatment with sample A, B, C, and D, respectively (Table 2). The sodium, potassium, phosphate and nitrate contents in the test crop were higher in treatment with sample B, C, and D relative to sample A (control) (Table 2).

Table 1: Physico-Chemical Parameters of Water Samples

Parameters	Sample A (Distilled water - control)	Sample B (Stream water)	Sample C (Tap water)	Sample D (Rain water)
Ph	6.60 ± 0.23	5.75 ± 0.14	5.83± 0.34	6.20 ±0.41
Salinity (mg/l)	0.00 ±0.00	0.12± 0.05	0.13 ± 0.03	0.00 ± 0.00
Conductivity µScm^{-1}	1.02± 0.09	266.00±0.27	268.00± 0.33	28.20±0.17
Turbidity (NTU)	0.00±0.00	6.87± 0.36	10.50± 0.21	0.80± 0.02
Total dissolved solids (mg/l)	2.06 ± 0.14	134.00±0.22	136.00 ± 0.26	14.10±0.52
Total suspended solids (mg/l)	0.00 ± 0.00	1.43 ± 0.16	1.64 ± 0.33	0.00 ± 0.00
Total alkalinity (mg/l $CaCO_3$)	17.02 ± 0.37	60.00 ± 0.24	90.00 ± 0.41	5.00 ± 0.35
Total hardness (mg/l $CaCO_3$)	9.20 ± 0.23	90.00 ± 0.35	120.00 ± 0.16	13.90 ± 0.29
Dissolved Oxygen (mg/l)	3.02± 0.26	6.56 ± 0.44	6.77± 0.38	5.88 ± 0.30
BOD (mg/l)	5.07± 0.10	19.70 ± 0.21	20.30 ± 0.32	31.24 ± 0.41
COD (mg/l)	12.08 ± 0.31	39.40 ± 0.44	41.62 ± 0.21	23.56 ± 0.35
Ca^{2+} (mg/l)	0.07± 0.01	34.95 ± 0.57	40.20 ± 0.39	7.41 ± 0.34

Mg^{2+} (mg/l)	0.04 ± 0.02	8.74 ± 0.33	10.50 ± 0.24	2.74 ± 0.51
Na^{+} (mg/l)	1.03 ± 0.04	16.48 ± 0.26	19.54 ± 0.52	4.40 ± 0.16
K^{+} (mg/l)	0.06 ± 0.02	5.47 ± 0.15	7.68 ± 0.24	1.42 ± 0.07
NO_3^{-} (mg/l)	0.00 ±0.00	0.27± 0.02	0.32 ± 0.02	0.14± 0.04
Cl^{-} (mg/l)	0.00 ±0.00	60.00 ± 0.43	70.00 ± 0.21	8.00 ± 0.25
SO_4^{2-} (mg/l)	0.00 ± 0.00	2.66 ± 0.22	2.86 ± 0.37	0.28 ± 0.42
PO_4^{-} (mg/l)	0.00 ± 0.00	0.54 ± 0.03	0.66± 0.02	0.06 ±0.01
HCO_3^{-} (mg/l)	0.00 ±0.00	3.00 ± 0.02	5.00 ± 0.04	1.00 ± 0.02
Fe (mg/l)	0.00 ± 0.00	0.24 ± 0.02	0.28 ± 0.04	0.01 ± 0.00
Mn (mg/l)	0.00 ± 0.00	0.02 ± 0.01	0.03 ± 0.01	0.00 ± 0.00
Zn (mg/l)	0.01 ± 0.00	0.06 ± 0.02	0.07 ± 0.03	-0.01±0.00
Pb (mg/l)	0.003±0.00	0.004±0.00	0.00 ± 0.00	-0.00±0.00
Cd (mg/l)	-0.00±0.00	0.02 ± 0.00	0.01 ± 0.00	-0.00 ±0.00
Cr (mg/l)	-0.00±0.00	0.02 ± 0.00	0.01 ± 0.00	-0.00±0.00
Cu (mg/l)	0.00 ± 0.00	0.04 ± 0.02	0.02 ± 0.00	-0.01± 0.00
Mean	2.12	28.24	31.78	5.72
LSD (P < 0.05)	0.25	1.07	1.42	1.23

Table 2: Mineral elements in the *Zea mays* L

Parameters	Sample A (Distilled water - control)	Sample B (Stream water)	Sample C (Tap water)	Sample D (Rain water)
Lead (mg/g)	0.00 3 ± 0.01	0.001 ± 0.01	0.002±0.02	0.004 ± 0,01
Cadmium (mg/g)	0.014 ± 0.01	0.015 ± 0.01	0.006± 0.02	0.002 ± 0.91
Chromium (mg/g)	-0.001± 0.01	-0.015 ± 0.02	0.005 ± 0.01	-0.002 ± 0.01
Iron (mg/g)	0.03 ±0.48	0.25 ±0.22	0.31 ±0.36	0.20 ± 0.31
Copper (mg/g)	0.01 ±0.00	0.01 ± 0.00	0.04 ± 0.02	0.07 ±0.02
Zinc (mg/g)	0.37 ±0.03	0.42 ± 0.01	0.21 ± 0.03	0.55 ±0.06
Manganese (mg/g)	0.02 ±0.01	0.08 ±0.02	0.05 ±0.01	0.08 ±0.03
Calcium (mg/g)	1.22 ± 0.31	7.86 ± 0.50	8.88 ± 0.62	6.15 ± 0.71
Magnesium (mg/g)	0.95 ± 0.42	3.32 ± 0.43	2.48 ±0.46	2.78 ±0.33
Sodium (mg/g)	0.80 ± 0. 85	3.87± 0.35	2.32 ±0.24	1.35± 0.32
Potassium (mg/g)	1.67 ± 0.66	7.98 ±0.44	7.48 ±0.32	4.80 ±0.71
NO_3 (mg/g)	0.36 ±0.13	0.40 ±0.30	0.77 ±0.59	0.66 ±0.19
PO_4 (mg/g)	0.46 ± 0.90	0.62 ±0.41	0.52 ±0.62	0.49 ±0.10
Mean	0.46	1.91	1.77	1.32
LSD (P < 0.05)	0.14	0.14	0.23	0.15

DISCUSSION

The physico-chemical parameters varied significantly ($P < 0.05$) between the varied sources of water samples. The pH values recorded in this study, however, were below the standard limit of 6.5-8.5 according to the World Health Organization (WHO) for safe drinking water in samples A and B, while samples C and D were within the normal range[23]. Conductivity values were lower than normal range of 1000 μScm^{-} by World Health Organization[23]. In this study, values of TSS in all the water samples were low, and within the permissible limits of WHO (≤ 30 mg/L)[23]. TDS can be taken as an indicator for the general water quality because it directly affects the visual quality of the water by increasing turbidity[2]. High concentrations of TDS limit the appropriateness of water as a drinking source and irrigation supply[3]. The acceptable range of TDS is 500 mg/L[23]. The results of both TSS and TDS were within the normal ranges. This implies that the water doesn't cause health problem to the consumers. The occurrence of heavy metals in drinking water higher than the standard concentration can have detrimental impacts on plant and animal health[16]. In this present study, the heavy metals contents such as Cu, Zn, Fe, Cd, Pb, and Cr were within the safe limits set by[23]. The ability of a solution to conduct an electrical current is governed by the movement of solutions and is dependent on the nature and number of the ionic species in that solution. This property is called electrical conductivity[3,22]. It is a useful tool to assess the purity of water. The permissible limit for electrical conductivity (EC) is 300 μScm^{-1}[23]. In this study, the EC values of all water samples were within permissible limits and the potable water is safe in terms of EC. In groundwater, hardness is mainly contributed by bicarbonates, carbonates, sulphates and chlorides of calcium and magnesium. The major hardness causing ions are calcium and magnesium[3]. The acceptable limit of total hardness is 300 mg/L while the maximum limit is 600 mg/L. The results for total hardness obtained in this study were all within the acceptable limit value WHO (500 mg/L)[23]. The concentration of chloride in water is an indicator of sewage pollution and this can have laxative effect. Atmospheric source or sea water contamination is the reason for immensity of the chloride concentration in groundwater which may exceed due to base-exchange phenomena, high temperature, domestic effluents, septic tanks and low rainfall[22]. The chloride content of water samples used in this study were within permissible limit of 250 mg/L prescribed by[23]. Mineral elements play a crucial role in the growth and development of plants[8,21]. Copper acts as a catalyst of redox reactions in the mitochondria, chloroplast, and cytoplasm of cells[7] or as an electron carrier during plant respiration[24]. However, Cu becomes toxic when its concentration in plant tissues rises above optimal levels[13]. Pb leads to the overproduction of reactive oxygen species (ROS) such as superoxide radicals (radical O) and hydrogen peroxide (H_2O_2) in plant cells[12]. Manganese influences processes such as photosynthesis, respiration and biosynthesis of enzymes such as malic enzymes, isocitrate dehydrogenases and nitrate reductases[19]. Some of the symptoms of Mn toxicity in plants are wrinkled leaves, darkening of leaf veins on older foliage, chlorosis and brown spots on aged leaves and black specks on the stems[17,18]. In general, bioaccumulation of heavy metals can have both direct and indirect impact on plant. Some of the direct toxic effects of high metal concentration in plant tissues include inhibition of cytoplasmic enzymes and damage to the cell structures due to oxidative stress[12].

CONCLUSION

This study has revealed that there is a direct link between the concentrations of the physico-chemical characteristics of irrigation water and the morphological as well as biochemical responses of plants. Thus, these physioco-chemical parameters can serve as indicators of elemental pollution in water. Finally, information generated through this study will be very useful in detecting the toxic levels of these pollutants.

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