



Impact of crude oil activities on some physicochemical characteristics of common vegetables consumed in southern Nigeria

Dokubo A^{1*}, Igwe F U¹, Nwosu C U²

¹ Department of Biochemistry, Rivers State University, Port Harcourt, Nigeria

² Department of Biochemistry, University of Port Harcourt, Port Harcourt, Nigeria

Abstract

Background: Vegetables are some of the edible plants mostly affected by environmental pollution and is of prime concern because it forms an integral part of many diets as a major source of essential minerals and vitamins. Insufficient consumption of vegetables has been listed as one of the risks factors contributing to the development of many degenerative diseases. Recently, researchers have developed interest in the pharmacological role of vegetables in fighting harmful biological processes of inflammation and overcoming nutritional problem. The present study was carried out to assess the physicochemical characteristics of vegetables obtained from markets, located in Ogoniland and Ozubulu, where cultivation and marketing of vegetables is a major occupation of the people.

Materials and Methods: Seven (7) commonly consumed vegetables were used for the study. They were randomly obtained from the local markets within the study area, cleaned and their physicochemical parameters investigated using standard methods as contained in AOAC, (2006).

Results: There was significant ($t=3.40$, $p=0.03$) decrease in pH and significant ($t=8.09$, $p=0.00$) decrease in ascorbic acid (vitamin C) content of the vegetables consumed in Ogoniland (7.45 ± 0.55 and 144.39 ± 21.66 mg/100g respectively) compared to those consumed in Ozubulu (8.20 ± 0.55 and 207.24 ± 27.65 mg/100g respectively). There was significant ($t=2.45$, $p=0.02$) decrease in Mg levels and significant decrease ($t=2.39$, $p=0.03$) in Ca levels of the vegetables from Ogoniland (3782.00 ± 455.10 and 3509.29 ± 618.93 mg/kg respectively) when compared to Ozubulu (4982.38 ± 767.14 and 4326.86 ± 907.08 mg/kg respectively). The result also showed significant ($t=1.24$, $p=0.03$ and $t=3.78$, $p=0.01$) increase in sulphates (6924.88 ± 1393.08 mg/kg) and chlorides (2030.70 ± 234.85 mg/kg) levels and significant decrease ($t=1.70$, $p=0.11$ and $t=4.35$, $p=0.00$) in nitrates (118.40 ± 7.18 mg/kg) and phosphates (97.33 ± 3.02 mg/kg) levels of vegetables from Ogoniland when compared to Ozubulu (5253.13 ± 505.42 mg/kg, 1768.90 ± 208.33 mg/kg) and (141.82 ± 8.67 mg/kg, 108.24 ± 2.55 mg/kg) respectively. The Pearson correlation indicated that pH, vitamin C and chloride showed strong significant negative correlation ($r=-0.76$, $p=0.04$, $r=-0.98$, $p=0.00$ and $r=-0.96$, $p=0.00$ respectively) while sulphates and nitrates showed moderate significant negative correlation ($r=-0.56$, $p=0.04$ and $r=-0.50$, $p=0.02$ respectively).

Conclusion: Vegetable samples collected from Ogoniland were more acidic and had lower micronutrient values compared to those from Ozubulu. This may be attributed to the environmental pollution of the area from crude oil activities. Soil and atmospheric pollution could contribute to nutrient deficiency in vegetables that may pose significant health risks to consumers.

Keywords: ogoniland, ozubulu, vegetables, physicochemical parameters, pollution

Introduction

Crude oil is said to be the pillar of Nigeria's economy (Oyedeji, 2016) ^[32]. Its production has contributed to approximately 80% of revenues generated to the Federal Government (Ojimba and Iyagba, 2012, Collins *et al.*, 2008) ^[27, 6]. Oil exploration activities take place mostly in the Niger Delta region, south of Nigeria (Chinda and Braide., 2000., Collins *et al.*, 2008) ^[5, 6]. Over the past decades, this region had experienced negative impact of crude oil exploration activities (Fentiman and Zabbey, 2015., Okhumode, 2017) ^[12, 28]. Communities in the region are often impacted by oil spillage and gas flaring affecting every living and non-living component of the environment (Osuji, 2001., Idodo-Umeh and Ogbeibu, 2010) ^[30, 16]. Crude oil spillages causes aquatic environment to be clogged with oil, the influence of tide and flood waters causes spilt oil to be rapidly distributed over large areas of farm lands increasing soil infertility, turning productive agricultural lands into wastelands and destruction of microorganisms that are beneficial to the soil (Odjuvwuederhie *et al.*, 2006, Lindén and Pålsson, 2013) ^[26, 21]. Gas flaring, a common

practice employed in the exploration and exploitation of crude oil, has devastating effect on the atmosphere, land and inhabitants of the region (Gobo *et al.*, 2010, Nwankwo and Ogagarue, 2011) ^[13, 24]. Gas flares emits hot sooths that are deposited on farm lands inhibiting photosynthesis, transpiration, respiration and plant growth (Ojimba and Iyagba, 2012) ^[27]. The continuous emission of highly toxic airborne pollutants such as nitrogen oxides and sulphur dioxide are linked to diseases such as asthma, cancer, lungs infections and other respiratory illness (Igwe *et al.*, 2016) ^[17]. It also causes depletion of ozone layer, turns rains to become acidic and affect soil physicochemical riders such as temperature, structure, nutrient status and pH (Odjuvwuederhie *et al.*, 2006) ^[26].

Vegetables are simply referred to as herbaceous plant parts that are fit for consumption. These constitute the stem, leaves, roots, flowers or fruits and are essential components of human diet. They supply protein, mineral, vitamins, fibre and other essential nutrients required to maintain health and prevent diseases (Falade *et al.*, 2003, Mohammed and Sharif, 2011) ^[10]. They also contain phytochemicals that

help to fight some harmful biological processes, exhibit antioxidant and anti-carcinogenic activity as well as cardioprotective and hepatoprotective activities (Tanumihardjo and Yang, 2005., Gupta and Prakash, 2011, Sikora and Bodziarczyk, 2012) [36, 14, 34]. Vegetables are often prepared from a single plant species or combination of different species to give taste, flavor and colour, and may be eaten raw or cooked (Marshall, 2001., Fasuyi, 2006., Acho *et al.*, 2014) [22, 11, 1]. There are numerous vegetables that are commonly consumed in different part of the world. The nutritional assessment as well as medicinal properties of many has been reported. There are increasing scientific evidence that consumption of vegetables decrease the risk of developing chronic diseases (Perez, 2002; Dias, 2012). Considering the numerous potential harmful effects of crude oil activities on the environment, this work is aimed at investigating the physicochemical parameters of selected vegetables cultivated in crude oil impacted and non crude oil impacted locations in southern Nigeria so as to determine any variation in the nutritive value of the vegetables consumed.

Materials and Methods

1. Study Locations

The study locations are Ogoniland in Rivers State, south-south Nigeria and Ozubulu in Anambra State, south-east Nigeria. In Ogoniland, crude oil exploration and exploitation activities were noted as common sources of land, water and air pollution (Okhumode, 2017; UNEP, 2011) [28], while Ozubulu is an area in Anambra State with arable land and negligible crude oil exploration and exploitation activity as no cases of crude oil pollution has been recorded. Commonly consumed vegetables produced from these areas and sold to residents within the local markets were selected randomly for the study.

2. Sample Collection and Identification

The vegetables used for the study are; *Vernonia amygdalina* (bitter leaf), *Telfaria occidentalis* (fluted pumpkin or ugu) *Talinum triangulare* (water leaf), *Gnetum africanum* (okazi), *Amaranthus hybridus* (green leaf), *Pterocarpus soyanki* (oha) and *Abelmoschus esculentus* (lady's finger or okro). The fresh vegetables were obtained from popular markets within the study locations and taken to the Plant Science and Biotechnology Department, University of Port Harcourt for authentication. The vegetables collected were labeled, stored and transported in black polythene bags. Each vegetable sample was removed from the bag, washed thoroughly with distilled water, to remove any contaminants, air-dried in the laboratory for 24 hours and oven-dried at 80°C for 24 hours. The dried samples were then powdered using a Teflon mortar and pestle, sieved with muslin cloth and stored in air-tight containers for further analysis.

3. Determination of physicochemical parameters of the vegetables

The physicochemical properties of the vegetables determined include; pH, Vitamin C, Alkalizing metals (Na, K, Mg, and Ca) and Anions (NO_3^- , SO_4^{2-} , PO_4^{3-} , Cl^-) using standard methods as described by AOAC, (2006).

3.1 Determination of pH

The pH of the vegetable samples was determined using a pH meter (PHS-25C, Jinoteh). 2g of the powdered vegetable sample was dissolved in 20cm³ of distilled water and filtered using Whatman No. 541 filter paper. The pH meter and combination electrode were calibrated using a two point calibration buffer solution of pH 7.0 and pH 4.0 respectively. The electrodes were inserted into the sample solutions one after the other. Figures displayed were recorded as the pH of the sample (Usman *et al.*, 2016) [38].

3.2 Determination of Vitamin C Content

The vitamin C (ascorbic acid) content of each vegetable sample was determined by Indophenol method (Akan *et al.*, 2010, Oluai *et al.*, 2014). Each vegetable sample solution was extracted with 10% glacial acetic acid and subsequently titrated with 0.5g/L dichlorophenol-indophenol (DCPIP) to a stable pink color

3.3 Digestion of the vegetable samples

The vegetable samples were digested by weighing 1.0g of the dried powdered sample into 250 ml beaker. Then, 20ml of nitric acid, perchloric acid and hydrochloric acid mixture, in the ratio 1:6:1 respectively, was added and heated on a hot plate until no brown fumes was seen. The digested samples were further mixed with 2ml of nitric acid, allowed to stand for 10 minutes and the solution made up to 100ml with distilled water. After cooling, the mixture was filtered through Whatman No. 541 filter paper (Dingkwet *et al.*, 2013) [8].

3.4 Determination of Alkalizing Metals

The alkalizing metals in the different vegetable samples were determined using Burk Scientific AAS, 205. After digestion and filtration, the filtrate was used for the analysis of Na, K, Mg and Ca using suitable hollow cathode lamps. The concentration of each metal in the sample was determined by the corresponding standard calibration curves using standard solutions of each element (Zafar *et al.*, 2010).

3.5 Determination of Anions

Determination of anions was done by weighing 1g of each vegetable sample into a crucible. 0.5g of anhydrous sodium carbonate was added, placed in an ignition tube and heated to a temperature of 630°C in a muffle furnace and crushed to fine powder after cooling. The powder was dissolved in 50ml distilled water and filtered using Whatman No. 42 filter paper. Suitable aliquot of the filtrate was used for the determination of Sulphates, Nitrates and Chlorides while the powdered form of the vegetable samples dissolved in 0.01M Hydrochloric acid was used for the determination of Phosphates (Babatunde and Ajibola, 2009) [4].

3.6 Determination of Nitrates (NO_3^-)

Nitrates in each of the vegetable samples were determined by Brucine method (Kolo *et al.*, 2010) [20]. 1.0ml of the digest was collected using a pipette and transferred into a test tube. 0.5ml of Brucine reagent and 2ml of concentrated sulphuric acid were added. The solution was heated to 100°C, cooled at room temperature and absorbance of the resulting solution measured at 410nm using a spectrophotometer.

3.7 Determination of Sulphates (SO₄²⁻)

The Turbidimetric method was used for the determination of sulphates in the sample (Babatunde and Ajibola, 2009)^[4]. 10ml of the digest was diluted with distilled water and made up to the 100ml mark of a 100ml volumetric flask. Barium chloride salt and few drops of glacial acetic acid were added and the turbidity of the resulting solution was measured at 420 nm using spectrophotometer

3.8 Determination of Phosphate (PO₄³⁻)

Phosphates were determined by the Ammonium molybdo-vanadate method (Kolo *et al.*, 2010)^[20]. 50cm³ of hydrochloric extract of each vegetable sample was filtered and the filtrate transferred to a flask. 25cm³ of ammonium molybdo-vanadate solution was added and mixed thoroughly. The content in the flask was allowed to stand for 10 minutes and the absorbance of the yellow color developed was measured at 400nm wavelength using a spectrophotometer

3.9 Determination of Chlorides (Cl⁻)

The determination of Chlorides in the vegetable samples was carried out by Mohr Method based on the fractional precipitation of AgCl by AgNO₃ (Jagessar and Sooknundun, 2014). 25ml of the vegetable sample digest was collected using a pipette and transferred into a clean conical flask. 1.0ml of potassium dichromate was added as an indicator and the solution titrated with 0.02M silver nitrate solution. The titre value obtained was used to calculate the chloride ion content in the sample.

Statistical Analysis of Data

Data were obtained in triplicate and expressed as mean ± Standard Deviation (SD). Statistical analyses were

performed by the students t-test (p<0.05) and Pearson correlation using SPSS version 20.0 software.

Results

The botanical classification and identification code of the commonly consumed vegetables selected for this study is indicated in Table1.

Table 1: General Identification of the Selected Vegetables

Identification Number	Local Name	Botanical Name
GA1	Okazi	<i>Gnetum africanum</i>
PS2	Oha	<i>Pterocarpus soyankii</i>
TO3	Ugu	<i>Telfaria occidentalis</i>
TT4	Water leaf	<i>Talinum triangulare</i>
AH5	Green leaf	<i>Amaranthus hybridus</i>
VA6	Bitter leaf	<i>Vernonia amygdalina</i>
AE7	Okra or lady's finger	<i>Abelmoschus esculentus</i>

Summary of results of physicochemical parameters of the selected vegetables from Ozubulu and Ogoniland are contained in Table 2 and presented Table 2. The results showed that vegetable samples from Ogoniland had pH range of 6.62 ± 0.60 to 8.16 ± 0.04 and vitamin C (ascorbic acid) range of (20.00 ± 0.00 to 310 ± 0.02) mg/100g. Vegetable samples from Ozubulu had pH range of 7.24 ± 0.04 to 8.84 ± 0.03 and ascorbic acid range of (70.01 ± 0.00 to 330.57 ± 0.02) mg/100g. Statistical analysis by paired sample t- test showed significant (t= 3.40, p= 0.03) decrease in pH and ascorbic acid values of vegetables consumed in Ogoni land (7.45 ± 0.55 and 144.39 ± 21.66) mg/100g compared to Ozubulu (8.20 ± 0.55 and 207.24 ± 27.65)mg/100g.

Table 2: Physicochemical Properties of Selected Vegetables in Ozubulu and Ogoniland

Parameters	Ozubulu	Ogoni	t-value	P=value
pH	8.20 ± 0.55	7.45 ± 0.55	3.40	0.03
Ascorbic acid (mg/100g)	207.24 ± 27.65	144.39 ± 21.66	8.09	0.00
Na (mg/kg)	220.10 ± 31.31	177.00 ± 48.17	1.24	0.23
K (mg/kg)	21946.33 ± 285.95	18409.86 ± 153.10	1.83	0.01
Mg (mg/kg)	4982.38 ± 767.14	3782.00 ± 455.10	2.45	0.02
Ca (mg/kg)	4326.86 ± 907.08	3509.29 ± 618.93	2.39	0.03
NO ₃ (mg/kg)	141.82 ± 8.67	118.40 ± 7.18	1.70	0.01
SO ₄ ²⁻ (mg/kg)	5253.13 ± 505.42	6924.88 ± 1393.08	1.24	0.23
PO ₄ ³⁻ (mg/kg)	108.24 ± 2.55	97.33 ± 3.02	4.35	0.00
Cl ⁻ (mg/kg)	1768.90 ± 208.33	2030.70 ± 234.85	3.78	0.01

Values are expressed as mean ± Standard Deviation (SD). (n=3)

Results obtained for the alkalizing minerals in the vegetables from Ogoniland showed that levels of Na ranged from (38.59 ± 0.03 to 688.81 ± 0.07) mg/kg, K ranged from 7850.67 ± 0.03 to 31321.00 ± 0.04) mg/kg, Mg ranged from 1207.33 ± 3.51 to 11398.00 ± 1.04) mg/kg and Ca ranged from (427.00 ± 0.00 to 9671.67 ± 4.50) mg/kg. Vegetables from Ozubulu had Na ranging from (39.00 ± 0.05 to 420.90 ± 0.03) mg/kg, K ranged from (8060.33 ± 1.53 to 43072.00 ± 1.73) mg/kg, Mg ranged from (1207.33 ± 3.51 to 11398.00 ± 1.04) mg/kg and Ca ranged from (917.33 ± 1.15 to 13973.66 ± 14.48) mg/kg.

Paired sample t- test showed that Na levels of vegetables from Ogoni land (177.00 ± 48.17 mg/kg) are not significantly (t= 1.24, p=0.23) different from Ozubulu (220.10 ± 31.31 mg/kg), despite the marked difference. On the other

hand, K levels of vegetables from Ogoniland (18409.86 ± 153.10 mg/kg) showed significant (t= 1.83, p=0.01) decrease when compared to those from Ozubulu (21946.33 ± 285.95 mg/kg). There was significant (t= 2.49, p= 0.02) decrease in Mg levels and significant decrease (t= 2.45, p= 0.03) in Ca levels of vegetables from Ogoniland (3782.00 ± 455.10 and 3509.29 ± 618.93 mg/kg) when compared to Ozubulu (4982.38 ± 767 and 4326.86 ± 907.08 mg/kg) respectively.

The values of anions analyzed in vegetables from Ogoniland indicated that nitrates ranged from (44.14 ± 0.04 to 148.40 ± 0.01) mg/kg, sulphates ranged from (688.90 ± 0.03 to 20666.71 ± 0.01) mg/kg, phosphates ranged from (71.78 ± 0.01 to 112.20 ± 0.01) mg/kg and chlorides ranged from (1200.00 ± 0.02 to 1546.40 ± 0.00) mg/kg. While those

from Ozubulu showed that nitrates ranged from (97.60±0.00 to 216.19±0.02) mg/kg, sulphates ranged from (710.19±0.00 to 7233.33±0.04) mg/kg, phosphates ranged from (81.52±0.03 to 118.61±0.50) mg/kg and chlorides ranged from (1200.00±0.02 to 4428.77±0.0) mg/kg.

Paired sample t- test showed significant ($t=1.24$, $p=0.03$ and $t=3.78$, $p=0.01$) increase in sulphates (6924.88 ±1393.08mg/kg) and chlorides (2030.70± 234.85mg/kg) levels and significant decrease ($t=1.70$, $p=0.01$ and $t=4.35$, $p=0.00$) in nitrates (118.40±7.18mg/kg) and phosphates (97.33 ±3.02mg/kg) levels of vegetables from Ogoniland when compared to Ozubulu (5253.13 ±505.42mg/kg, 1768.90 ±208.33 mg/kg) and (141.82 ±8.67mg/kg, 108.24 ±2.55mg/kg) respectively.

The Pearson correlation coefficient matrix for the parameters is presented in Table 3. The significance was set

at ($p=0.01$, $p<0.05$). The computed statistical results indicated that the physicochemical parameters such as pH, vitamin C (ascorbic acid) and chloride showed strong significant negative correlation ($r=-0.76$, $p=0.04$, $r=-0.98$, $p=0.00$ and $r=-0.96$, $p=0.00$ respectively) while sulphates, nitrates and phosphates showed moderate significant negative correlation ($r=-0.56$, $p=0.04$, $r=-0.50$, $p=0.02$ and $r=-0.66$, $p=0.01$ respectively). The alkalinizing metals, Na and K showed weak negative correlation ($r=-0.21$, $p=0.50$ and $r=-0.35$, $p=0.56$) while Mg and Ca showed moderate significant correlation ($r=-0.58$, $p=0.04$, $r=-0.516$, $p=0.04$). Also, strong significant negative correlation was indicated for pH of vegetables from Ogoniland with ascorbic acid, Mg and Ca and indicated moderate significant negative correlation with sulphates and chlorides of vegetables from Ozubulu.

Table 3: Correlation (r-value) of the Physicochemical Parameters of Vegetable Samples from Ogoni and Ozubulu Markets

Parameters Ogoni/Ozubulu	r value	Parameters Ogoni/Ozubulu	r value
pHOg/ pHOz	-0.76** 0.04	pHOg/ Asc. acid Oz	-0.56* 0.02
Asc. acid Og/ Asc. Acid Oz	-0.98** 0.00	pHOg/ NaOz	0.13 0.58
NaOg/ NaOz	-0.21 0.50	pHOg/ KOz	0.29 0.21
K Og/ KOz	-0.35 0.56	pHOg/ MgOz	-0.71** 0.04
MgOg/ MgOz	-0.58** 0.02	pHOg/ CaOz	-0.79* 0.02
CaOg / CaOz	-0.52** 0.04	pHOg/ NO ₃ Oz	-0.46* 0.03
NO ₃ Og/ NO ₃ Oz	-0.50* 0.02	pHOg/ SO ₄ ²⁻ Oz	-0.49* 0.025
SO ₄ ²⁻ Og/ SO ₄ ²⁻ Oz	-0.56* 0.04	pHOg/ PO ₄ ³⁻ Oz	0.22 0.12
PO ₄ ³⁻ Og/ PO ₄ ³⁻ Oz	-0.66** 0.03	pHOg/ ClOz	-0.66** 0.00
ClOg/ ClOz	-0.96** 0.00	-	-

*. Correlation is significant at the 0.05 level (2-tailed). **. Correlation is significant at the 0.01 level (2-tailed). Oz= Ozubulu, Og= Ogoniland, Asc. Ascorbic acid

Discussion

Crude oil pollution has direct and indirect effect on the environment including plants and animals. Vegetables are some of the edible plants mostly affected by environmental pollution and it is of prime concern due to the high rate of consumption by humans. Inhabitants of communities located in the study area cultivate these vegetables in large quantity and consume them directly or bring them to the open markets for sale to other consumers (Osam *et al.*, 2010). Crude oil exploitation and production activities can directly or indirectly affect the quality of vegetables consumed in the area as seen in this study. Gas flaring and artisanal crude oil refining activities give rise to particulate matter, acid gases and acidic rain (Gobo *et al.*, 2010, Nwankwo and Ogagarue, 2011) [13, 24]. Acid deposition directly or indirectly on the leaves of plants interrupts the evaporation of water and gases, inhibiting the conversion of nutrients and water into useful metabolite (Okhumode, 2017) [28]. Consequently, nutrient deficiency in the impacted vegetables may arise. The mechanical effect of particulate matter can also hamper metabolism and growth yielding poor quality vegetables which may pose significant health risks to consumers.

Vegetables are essential component of human diets because they provide vital nutrients and prevent the occurrences of many degenerative diseases (Falade *et al.*, 2003) [10]. In most cases fresh and unprocessed vegetables are sold to consumers in order to guarantee optimal nutritional qualities. Consequently, most vegetables are consumed raw or slightly cooked (Acho *et al.*, 2014) [1] but some may be partly processed, due to their perishable nature and short biodegradation time at room temperature. In recent times,

insufficient consumption of vegetables has been listed as one of the risks factors contributing to the prevalence of non-communicable diseases (Hu, 2003) [15].

Vegetables contain several essential components that participate in metabolism and other biochemical pathways such as antioxidant defense and anti-inflammatory reactions. They also act as buffer to acids that are generated during body metabolism (Jolly *et al.*, 2013) [19]. Consumption of vegetables is one of the ways minerals and vitamins are provided for the body to thrive. Recently researchers have also developed interest in the pharmacological role of vegetables in fighting harmful biological processes (Perez, 2002, Dokubo *et al.*, 2017) [9].

From this study, the physicochemical parameters investigated in the vegetables collected from Ogoniland showed significant decrease in pH and ascorbic acid. Correlation analysis was carried out to assess the relationship between the physicochemical parameters of vegetables from Ozubulu and Ogoni locations. Pearson's correlation coefficient indicated strong significant negative correlation of pH and ascorbic acid with those from Ozubulu. The pH of any sample is a measure of the acidity or alkalinity of the sample. Decrease in pH implies acidity while increase in pH implies alkalinity of the samples. pH is an important physicochemical rider that influence the solubility and availability of nutrients in vegetables (Odjuvwuederhie *et al.*, 2006) [26]. The lower pH value of vegetables from Ogoniland implies that these vegetables are more acidic than those from Ozubulu. Predominant consumption of vegetables that are acidic can create an acidic environment that may hamper buffering capacity of the blood, setting the stage for numerous disease conditions

such as osteoporosis, fungal infection and rapid aging thereby reducing life expectancy (Jolly *et al.*, 2013)^[19].

Ascorbic acid, also known as vitamin C, is an essential nutrient required for the repair of worn out tissues, act as a cofactor in some enzymatic reactions and act as an antioxidant in the protection against oxidative stress (Squires, 2011)^[35]. The low yield of such essential vitamin is indicative of nutrient deficient vegetables. Similar results were also reported by Nwaoguikpe, (2011)^[25] on the ascorbic acid content of some selected vegetable species in an oil polluted soil. Consumption of such nutrient deficient vegetables can result to high levels of acid in the body, giving rise to a number of degenerative diseases (Hu, 2003)^[15].

The distribution of alkalinizing minerals and anions are also affected in the vegetables from Ogoniland compared to Ozubulu. Alkalinizing metals help the body to maintain an alkaline pH critical for biochemical reactions to occur. Consumption of vegetables with low levels of these minerals can lead to dietary deficiencies which may predispose individuals to development of chronic diseases, decreased energy production in cells, inhibit the ability to repair damaged cells, ability to detoxify heavy metals and prolong the body's ability to absorb other minerals and nutrients (Hu, 2003., Jolly *et al.*, 2013)^[15, 19]. Pearson's correlation table indicated that in Ogoni land pH of the selected vegetables showed significant negative correlation with ascorbic acid, Mg, Ca, nitrates, sulphates and chlorides with vegetables from Ozubulu.

Conclusion

Common vegetables consumed in Ogoni land had significantly lower pH, vitamin C, magnesium and calcium content when compared to those from Ozubulu. These observed effects may be attributed to crude oil exploration and exploitation activities prevalent in Ogoni land compared to Ozubulu. Crude oil pollution affects nutrient absorption, synthesis and availability in plants thereby producing nutrient deficient vegetables. Continuous consumption of nutrient deficient vegetables may pose significant health risk to consumers and the population. Therefore, adequate pollution control measures and environmental education are necessary to safeguard the potential harmful effects associated with crude oil pollution in southern Nigeria

References

1. Acho CF, Zoue LT, Akpa EE, Yapo VG, Niamke SL. Leafy vegetables consumed in Southern Côte d'Ivoire: a source of high value nutrients. *Journal of Animal and Plant Sciences*,2014;20(3):3159-3170.
2. Akan JC, Abdulrahman FI, Sodipo OA, Lange AG. Physicochemical Parameters in Soil and Vegetable Samples from Gongulon Agricultural Site, Maiduguri, Borno State, Nigeria. *Journal of American Science*,2010;12(6):78-87.
3. AOAC. Official Methods of Analysis, 15th edition, Washington, D. C, Association of Official Analytical Chemists, 2006.
4. Babatunde OA, Ajibola VO. Determination of some anions along the profile of irrigated farm sites. *Environmental Research Journal*,2009;3(3):101-106.
5. Chindah AC, Braide SA. The Impact of Oil Spills on the Ecology and Economy of the Niger Delta". In *Proceedings of the Workshop on Sustainable Remediation Development Technology* held at the Institute of Pollution Studies, Rivers State University of Science and Technology, Port Harcourt, 2000.
6. Collins N, Ugochukwu C, Jürgen E. Negative impacts of oil exploration on biodiversity management in the Niger Delta area of Nigeria. *Impact Assessment and Project Appraisal*,2008;26(2):139-147.
7. Dias JS. World Importance, Marketing and Trading of Vegetables. *Acta Horticulturae*,2011: 21(9):153-169.
8. Dingkwoet DJ, Danladi SM, Mafulul SG. Comparative Study of Some Heavy and Trace Metals in Selected Vegetables from four Local Government Areas of Plateau State, Nigeria. *Journal of Environmental Science, Toxicology And Food Technology*,2013;3(6):86-93.
9. Dokubo A, Uwakwe AA, Amadi BA. Effects of Aframomum Sceptrum and Parinari Congensis Seed Extracts in Alloxan Induced-Diabetic Wistar Albino Rats. *International Journal of Agriculture and Earth Science*,2017;5(3):21-33.
10. Falade OS, Sowunmi OR, Oladipo A, Tubosun A, Adewusi SRA. The level of organic acids in some Nigerian fruits and their effects on mineral availability in composite diets. *Pakistan Journal of Nutrition*,2003;2:82-88.
11. Fasuyi OA. Nutritional potentials of some tropical vegetable leaf meals: Chemical characterization and functional properties. *African Journal of Biotechnology*,2006;5:49-53.
12. Fentiman A, Zabbey N. Environmental Degradation and Cultural Erosion in Ogoniland: A Case Study of the Oil Spills in Bodo. *Extractives Industries and Society International Journal*,2015;2:615-624.
13. Gobo A, Richard G, Ubong I. Health Impact of Gas Flares on Igwuruta/Umuechem Communities in Rivers State. *Journal of Applied Science and Environmental Management*,2010;13:27-33.
14. Gupta S, Prakash J. Nutritional and sensory quality of micronutrient-rich traditional products incorporated with green leafy vegetables. *International Food Research Journal*,2011;18:667-675.
15. Hu FB. Plant based food and prevention of cardiovascular disease: An overview *American Journal of Clinical Nutrition*,2003;78(3):5544-5551.
16. Idodo Umeh G, Ogbeibu AE. Bioaccumulation of the heavy metals in cassava tubers and plantain fruits grown in soils impacted with petroleum and non-petroleum activities. *Research Journal of Environmental Sciences*,2010;4(1):33-41.
17. Igwe FU, Dokubo A, Ukpaka CP. Overview of Crude Oil Toxicity: A Potential Health and Environmental Hazard In the Niger Delta. *Nigerian Journal Of Oil And Gas Technology*,2016;2(2):94-104.
18. Jagessar RC, Sooknundun L. Chloride ion content from nine selected undetermined areas of Coastal Guyana. *Agriculture, Ecology and Environment*.2014, 2011, 69-81.
19. Jolly YN, Islam A, Akbar S. Transfer of metals from soil to vegetables and possible health risk assessment. *Springer Plus*,2013;2(1):385.
20. Kolo BG, Ogugbuaja VC, Dauda M. Study on the level of sulphates, phosphates, and nitrates in water and

- aqueous sediments of lake Chade Basin area of Borno State in Nigeria. *Continental Journal of Water, Air, and Soil Pollution*,2010:1:13-18.
21. Lindén O, Pålsson J. Oil Contamination in Ogoniland, Niger Delta. *Ambio*,2013:42(6):685-701.
 22. Marshall F. Agriculture and use of wild and weedy greens by the Piik Ap Oom Okiek of Kenya. *Economic Botany*,2001:55:32-46.
 23. Mohammed MI, Sharif N. Mineral composition of some leafy vegetables consumed in Kano, Nigeria. *Nigerian Journal of Basic and Applied Science*,2011:19:208-211.
 24. Nwankwo C, Ogagarue D. Effects of Gas Flaring on Surface and Ground Waters in Delta State Nigeria. *Journal of Geology Mining Research*,2011:3:131-136.
 25. Nwaoguikpe RN. The Effect of Crude Oil Spill on the Ascorbic Acid Content of Some Selected Vegetable Species: Spinach Oleraceae, Solanum Melongena and Talinum Triangulare in an Oil Polluted Soil. *Pakistan Journal of Nutrition*,2011:10:274-281.
 26. Odjuvwuederhie EI, Douglasson GO, Nkem FA. The effect of oil spillage on crop yield and farm income in Delta State, Nigeria. *Central European Journal of Agriculture*,2006:7(1):41-48.
 27. Ojimba TP, Iyagba AG. Effects of Crude Oil Pollution on Horticultural Crops in Rivers State, Nigeria. *Global Journal of Science Frontier Research Agriculture and Biology*,2012:12(4):1-9.
 28. Okhumode HY. Addressing environmental health problems in Ogoni land through implementations of United Nations Environmental Program Recommendations: Environmental Management Strategies. *Environments*,2017:4(28):1-19.
 29. Osam MU, Wegwu MO, Uwakwe AA. The Omoku Old Pipeline Oil Spill: Total Hydrocarbon Content of Affected Soils and the Impact on the Nutritive Value of Food Crops. *Archives of Applied Science Research*,2011:3:514-521.
 30. Osuji LC. Post impact assessment of oil pollution in Agbada west plain of Niger Delta, Nigeria: field reconnaissance and total extractable hydrocarbon content. *Journal of Applied Sciences & Environmental Management*,2001:5(35):156-1578.
 31. Oulai P, Zoue L, Megnanou RM, Doue R, Niamke S. Proximate composition and nutritive value of leafy vegetables consumed in Northern Côte d'Ivoire. *European Scientific Journal*,2012:6(10):212-227.
 32. Oyedeji B. Managing Nigeria without Oil. *International Journal of Innovative Legal and Political Studies*,2016:4(3):1-16.
 33. PÉrez CE. Fruits and vegetables consumption. *Health Reports*,2002:3(13):23-30.
 34. Sikora E, Bodziarczyk I. Composition and antioxidant activity of kale (*Brassica oleracea* L. var. Acephala) raw and cooked. *Acta Science Technology Aliment*,2012:11:239-248.
 35. Squires VR. The role of food, Agriculture, Forestry and Fishes in Human nutrition,2011:4:121.
 36. Tanumihardjo SA, Yang Z. Epidemiology of Health Effects In: B. Caballero, L. Allen, A. Prentice, Eds., *Encyclopedia of Human Nutrition*, 2nd Edition, Elsevier, Oxford, 2005, 339-345.
 37. UNEP. Environmental Assessment of Ogoniland. United Nations Environment Program Report, 2011. www.unep.org
 38. Usman B, Kolo B, Lawan M, Teri DM. Physicochemical Characteristics, Heavy Metal and ions in Soil and Vegetable Samples from Wandali, Kusar Local Government, Borno State, Nigeria. *Applied Research Journal*,2016:7(2):320-327.
 39. Zafar M, Khan MA, Ahmad M, Jan G, Sultana S, Ullah K, *et al.* Elemental analysis of some medicinal plants used in traditional medicine by atomic absorption spectrophotometer (AAS). *Journal of Medicinal Plants Research*,2010:4(19):1987-1990.