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# Evaluation of the Impact of Oil and Gas Pollutants on the Chemical Composition of *Abelmoschus esculentus Moench* and *Pterocarpus mildbraedii Harms.*

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**ABSTRACT:**

The phytochemical, proximate, mineral and vitamin contents of *Abelmoschus esculentus Moench* and *Pterocarpus mildbraedii Harms* were investigated. Plant samples were harvested from Polluted Environment (PE) at Izombe in Oguta Local Government Area- an oil drilling and gas flaring environment. The results obtained were compared to identical vegetables harvested from Eziobodo in Owerri West Local Government Area, designated as Unpolluted Environment (UPE). Our result showed that *A. esculentus* and *P. mildbraedii* have excellent nutritional value, which can confer biochemical and physiological advantage to humans. The quantitative proximate composition showed that the carbohydrate and ash contents of samples harvested from PE differed significantly (P<0.05) from samples obtained from unpolluted environment. The protein, crude fibre, moisture and total fat contents of samples from PE differed non significantly (P<0.05) when compared with samples obtained from UPE. The phytochemical contents of *A. esculentus* and *P. mildbraedii* were significantly higher in samples from UPE than in samples from PE. The mineral and vitamin contents were also determined. The concentration of nutritionally important macro and micro elements indicates that the two vegetable samples studied are rich sources of minerals and, therefore, can be used to improve the diet of both humans and livestock. This study also showed that environmental pollutants emanating from the activities of oil and gas industries can impact negatively on some important chemical and nutritive compositions of edible vegetables.

**Keywords:**
Oil and gas, Pollution, Phytochemicals, Vitamins, Oha, Okra.

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## INTRODUCTION

Nigeria, a major producer of crude oil, benefits as well as suffers from the positive and negative effects of crude oil drilling and gas flaring (Adeniye *et al.,* 1983). Gas flaring is the unscientific burning of excess hydrocarbons gathered in an oil/gas production flow station. Gas flaring is a major source of pollution in Nigeria's Niger Delta because it is the preferred means of disposing waste gas associated with oil exploitation in that region by many multinational oil companies that operate its fields. Gas flaring releases carbon monoxide, oxides of sulphur and nitrogen, hydrocarbons, soot and heavy metals (Coker, 2007; Ikoro, 2003). These pollutants actually interfere with growth and survival of living organisms in such environment especially in plants. It pollutes seedlings and fruits of plants which in turn have a devastating effect on humans who consume them. Such effects include respiratory or cardiovascular diseases. This study used *Abelmoschus esculentus Moench* and leaves of *Pterocarpus mildbraedii Harms*, two commonly consumed indigenous vegetables to evaluate the biochemical effects of these environmental pollutants.

*Abelmoschus esculentus Moench* (local name, Okra) and leaves of *Pterocarpus mildbraedii Harms* (local name, Oha) are vegetables commonly consumed as a source of food and medication for their high content of nutrients and phytochemicals and mainly used for soup preparation. Consumption of vegetables provide taste, palatability, increases appetite and provides fiber for digestion and to prevent constipation. They play key roles in neutralizing acids produced during digestion of proteins and fatty foods and also provide valuable roughages which helps in movement of food in the intestine. Some of these vegetables possess the ability to reduce or reverse so many disease conditions and disorders such as those which require a reduced intake of glucose (diabetes) (Mcdowell, 2001: Ogbonnia *et al*., 2008). These vegetables can be deeply affected by pollution.

The most glaring sight in gas production flow station is the ten-meter-high flame that burns continuously from vertical pipes at many facilities owned by oil companies. These vertical pipes are fed with gas given off during production. Gas flaring, for about four decades has contributed to the high pollution level, and the ecosystem of Izombe may have been impacted negatively. A good example of such negative effect is high soil acidity that creates chemical and biological conditions which may be harmful to the soil and plants (Nwaugo *et al*., 2006). One of these conditions is the reduction in the capacity of plants to absorb cations (Wild *et al.,* 2005). The higher acidic nature of soil is attributable to high concentrations of sulphur dioxide and particulates from gases flared into the atmosphere which is washed back to the soil as acid rain.

This study has two objectives, first to contribute to the knowledge of nutritional and antinutritional composition of *A. esculentus Moench* and *P. mildbraedii Harms*. Secondly, to evaluate the effect of environmental pollution resulting from crude oil exploration and exploitation and other industrial processes within the area of study. The arable nature and vast land mass of Izombe, confers it the status of food basket of Imo State, Nigeria.

## MATERIALS AND METHODS

### Collection and preparation of plant samples

Samples of *A. esculentus Moench* and *P. mildbraedii Harms* were obtained at Izombe, in Oguta Local Government Area and at Eziobodo, in Owerri West Local Government Area both in Imo state, Nigeria and identified by a plant taxonomist in the Federal University of Technology, Owerri (FUTO). Izombe is a rainforest ecosystem, which hosts multinational industries specialized in crude oil exploration and exploitation. Flaring of gases constitutes the major method of waste gas disposal at these oil fields. Situate to these oil fields are communities of indigenous inhabitants whose occupation are subsistence and semi-commercial farming. Eziobodo is also within the rainforest region of Nigeria, occupied by indigenous and FUTO students population. It has no known industrial activities, except few automobiles that convey inhabitants in and out of the village. Samples were sorted by removing extraneous materials, spoilt and unhealthy ones. After washing, okro samples were carefully sliced. The samples were oven dried, macerated, sieved and properly stored.

**Evaluation of proximate composition**

The method described by James (1995) and Onwuka (2005) were used to determine crude fiber. Fat content was determined by the method of Min and Boft (2003). Moisture content was determined by the method of AOAC (1990). The sample's total protein content was determined by microkjeldhal method described by James (1995). Protein concentration was obtained by determining total nitrogen and multiplied by the factor- 6.25. Carbohydrate contents was calculated using the arithmetical difference method described by Pearson (1976) and James (1995).

**Evaluation of phytochemical content**

Tannin content of samples were determined by Folin-Denis colorimetric method (Kirk and Sawyer, 1998). Saponin, alkaloid and flavonoid were done by method described by Harborne, (1973). The spectrophotometric method as described by Griffiths and Thomas (1981) was used for determining phytate content. Determinations were done in triplicates and results were expressed as averages of percent values on dry weight basis.

**Evaluation of vitamins content**

Retinol, ascorbic acid and α-tocopherol contents in the samples were determined using the method of Association of Vitamin Chemist as described by Kirk and Sawyer (1998).

**Evaluation of mineral content**

Some mineral contents were determined by atomic absorption spectrophotometer (James, 1995). The dry samples were burnt to ashes to remove all organic materials leaving inorganic ash. The resulting ash was dissolved in 10 ml of 2 M HCl solution and diluted to 100 ml with distilled water in a volumetric flask. The mixture was filtered and the resulting extract was used for the specific evaluation of copper, zinc and iron. Sodium, potassium, calcium and magnesium were determined with the aid of Jaway digital flame photometer. Phosphorus was determined as phosphate by the vanadomolybdate colorimetric method (Pearson, 1976)

**Table 1: Proximate composition (%) of *Abelmoschus esculentus Moench***

| Environment of sampling | Carbo- hydrates | Crude Protein | Ash | Crude Fibre | Moisture | Total Fat |
|---|---|---|---|---|---|---|
| Polluted | 32.47±2.22$^{a}$ | 14.28±0.30$^{a}$ | 13.78±0.40$^{a}$ | 22.13±1.40$^{a}$ | 10.52±0.89$^{a}$ | 6.82±0.90$^{a}$ |
| Unpolluted | 37.94±1.78$^{b}$ | 12.67±0.07$^{a}$ | 7.99±0.16$^{b}$ | 21.83±0.23$^{a}$ | 12.71±1.71$^{a}$ | 6.85±0.03$^{a}$ |

**Values (mean ± SD of triplicate determinations) with different superscripts per column are significantly (P<0.05) different.**

**Table 2: Proximate Composition (%) of *Pterocarpus mildbraedii Harms***

| Environment of sampling | Carbo- hydrates | Crude Protein | Ash | Crude Fibre | Moisture | Total Fat |
|---|---|---|---|---|---|---|
| Polluted | 29.38±1.24$^{c}$ | 8.06±1.43$^{c}$ | 19.40±0.57$^{c}$ | 17.65±0.79$^{c}$ | 22.37±1.18$^{c}$ | 3.14±0.33$^{c}$ |
| Unpolluted | 34.82±0.30$^{d}$ | 9.67±0.07$^{c}$ | 12.05±0.18$^{d}$ | 16.58±0.21$^{c}$ | 23.67±0.29$^{c}$ | 3.21±0.06$^{c}$ |

**Values (mean ± SD of triplicate determinations) with different superscripts per column are significantly (P<0.05) different.**

**Statistical analysis**

Data obtained were expressed as means± standard deviation. Statistical Package for the Social Sciences (SPSS) was used for the Analysis of Variance (ANOVA) for the test of significant difference between means (P<0.05).

**RESULTS**

The proximate contents of *A. esculentus* and *P. mildbraedii* are presented in Tables 1 and 2 respectively. Results obtained from unpolluted environment (UPE) showed that *A. esculentus* have higher content of carbohydrate, protein, fibre and total fat compared to *P. mildbraedii.* However, higher ash and moisture content were observed in *P. mildbraedii* when compared to *A. esculentus* from UPE. Carbohydrate content in samples obtained from polluted environment (PE) were significantly (P<0.05) lower than the UPE. But the ash contents were significantly higher in samples from PE. The protein, crude fiber, moisture and total fat contents of the samples showed no significant difference.

Results of phytochemical analysis are presented in tables 3 and 4. The concentrations of phytochemicals were significantly higher (P<0.05) in samples from PE. Also, the phytochemical contents of *P. mildbraedii* from PE were higher than that of *A. esculentus* from PE. The highest concentrations of phytochemicals were observed in flavonoids (0.54±0.02%) and tannin (1.83±0.01%) from *A. esculentus* and *P. mildbraedii* respectively from PE. However, alkaloids and tannins contents were highest in *A. esculentus* and *P. mildbraedii* respectively from UPE.

Vitamin contents were presented in tables 5 and 6. Vitamin A concentration in *A. esculentus* and *P. mildbraedii* were 627.59±0.47 mg/100g and 375.48±0.18 mg/100g respectively, indicating the highest vitamin content in the samples. Also, vitamin C and $B_5$ contents in samples from UPE were significantly higher (P<0.05) when compared to samples from PE. Similarly *P. mildbraedii* have significantly higher value of vitamin $B_5$ (189.33±2.31 mg/100g) compared to *A. esculentus* from UPE. In *A. esculentus* (table 5), all the vitamins determined were significantly (P<0.05) lower except vitamin $B_5$, vitamin $B_9$ and vitamin E in samples from PE. Also, samples of *P. mildbraedii* from PE when compared with samples from UPE showed significantly lower content in all the vitamins (table 6) except in vitamin $B_2$, vitamin $B_3$ and vitamin E.

The mineral contents are shown in tables 7 and 8. The concentrations of copper, iron, zinc and lead in *A. esculentus* from PE were significantly higher (P<0.05)

**Table 3: Phytochemical Composition (%) of *Abelmoschus esculentus Moench***

| Environment of sampling | Saponins | Tannins | Phytates | Alkaloids | Phenols | Flavonoids |
|---|---|---|---|---|---|---|
| Polluted | 0.33±0.03[a] | 0.37±0.01[a] | 0.23±0.01[a] | 0.43±0.01[a] | 0.26±0.04[a] | 0.54±0.02[a] |
| Unpolluted | 0.12±0.05[b] | 0.20±0.01[b] | 0.09±0.01[b] | 0.27±0.09[b] | 0.11±0.00[b] | 0.24±0.02[b] |

**Values (mean ± SD of triplicate determinations) with different superscripts per column are significantly (P<0.05) different.**

**Table 4: Phytochemical Composition (%) of *Pterocarpus mildbraedii Harms* Vegetables**

| Environment of sampling | Saponins | Tannins | Phytates | Alkaloids | Phenols | Flavonoids |
|---|---|---|---|---|---|---|
| Polluted | 0.41±0.02[c] | 1.83±0.00[c] | 0.37±0.01[c] | 0.57±0.01[c] | 0.44±0.02[c] | 0.63±0.01[c] |
| Unpolluted | 0.23±0.08[d] | 1.56±0.14[d] | 0.15±0.01[d] | 0.28±0.12[d] | 0.35±0.00[d] | 0.45±0.08[d] |

**Values (mean ± SD of triplicate determinations) with different superscripts per column are significantly (P<0.05) different.**

**Table 5: Vitamin Content (mg/100g) of *Abelmoschus esculentus Moench***

| Environment of sampling | Vitamin A | Vitamin $B_1$ | Vitamin $B_2$ | Vitamin $B_3$ | Vitamin $B_5$ | Vitamin $B_6$ | Vitamin $B_9$ | Vitamin C | Vitamin E |
|---|---|---|---|---|---|---|---|---|---|
| Polluted | $592.78 \pm 19.69^{a}$ | $0.02 \pm 0.02^{a}$ | $0.05 \pm 0.01^{a}$ | $0.83 \pm 0.10^{a}$ | $21.00 \pm 2.52^{a}$ | $0.58 \pm 0.02^{a}$ | $0.67 \pm 0.11^{a}$ | $68.41 \pm 2.31^{a}$ | $1.52 \pm 0.02^{a}$ |
| Unpolluted | $627.59 \pm 0.47^{b}$ | $0.08 \pm 0.01^{b}$ | $0.08 \pm 0.01^{b}$ | $1.12 \pm 0.01^{b}$ | $23.33 \pm 2.31^{a}$ | $0.81 \pm 0.10^{b}$ | $0.73 \pm 0.08^{a}$ | $78.03 \pm 1.02^{b}$ | $1.88 \pm 0.17^{a}$ |

**Values (mean $\pm$ SD of triplicate determinations) with different superscripts per column are significantly ($P<0.05$) different.**

**Table 6: Vitamin Content (mg/100g) of *Pterocarpus mildbraedii Harms* Vegetables**

| Environment of sampling | Vitamin A | Vitamin $B_1$ | Vitamin $B_2$ | Vitamin $B_3$ | Vitamin $B_5$ | Vitamin $B_6$ | Vitamin $B_9$ | Vitamin C | Vitamin E |
|---|---|---|---|---|---|---|---|---|---|
| Polluted | $302.57 \pm 7.01^{c}$ | $0.07 \pm 0.02^{c}$ | $0.04 \pm 0.01^{c}$ | $0.65 \pm 0.09^{c}$ | $175.22 \pm 6.97^{c}$ | $0.25 \pm 0.08^{c}$ | $0.53 \pm 0.17^{c}$ | $85.29 \pm 1.79^{c}$ | $1.97 \pm 0.18^{c}$ |
| Unpolluted | $375.48 \pm 0.18^{d}$ | $0.12 \pm 0.00^{d}$ | $0.06 \pm 0.01^{c}$ | $0.57 \pm 0.02^{c}$ | $189.33 \pm 2.31^{d}$ | $0.59 \pm 0.05^{d}$ | $0.89 \pm 0.02^{d}$ | $99.15 \pm 2.69^{d}$ | $2.27 \pm 0.17^{c}$ |

**Values (mean $\pm$ SD of triplicate determinations) with different superscripts per column are significantly ($P<0.05$) different.**

**Table 7: Mineral Content (mg/100g) of *Abelmoschus esculentus Moench*.**

| Environment of sampling | Magnesium | Calcium | Phosphorus | Sodium | Potassium | Copper | Iron | Zinc | Lead |
|---|---|---|---|---|---|---|---|---|---|
| Polluted | $22.17 \pm 1.39^{a}$ | $70.23 \pm 2.02^{a}$ | $57.35 \pm 0.59^{a}$ | $6.34 \pm 0.46^{a}$ | $107.63 \pm 4.45^{a}$ | $0.42 \pm 0.15^{a}$ | $0.95 \pm 0.26^{a}$ | $0.48 \pm 0.14^{a}$ | $0.65 \pm 0.07^{a}$ |
| Unpolluted | $39.60 \pm 1.39^{b}$ | $82.83 \pm 2.32^{b}$ | $68.28 \pm 0.46^{a}$ | $7.47 \pm 0.23^{a}$ | $130.40 \pm 6.55^{b}$ | $0.06 \pm 0.01^{b}$ | $0.74 \pm 0.25^{b}$ | $0.32 \pm 0.07^{b}$ | $0.35 \pm 0.10^{b}$ |

**Values (mean $\pm$ SD of triplicate determinations) with different superscripts per column are significantly ($P<0.05$) different.**

**Table 8: Mineral Content (mg/100g) of *Pterocarpus mildbraedii Harms* Vegetables.**

| Environment of sampling | Magnesium | Calcium | Phosphorus | Sodium | Potassium | Copper | Iron | Zinc | Lead |
|---|---|---|---|---|---|---|---|---|---|
| Polluted | $48.67 \pm 4.38^{c}$ | $64.38 \pm 3.95^{c}$ | $409.89 \pm 0.43^{c}$ | $17.16 \pm 1.71^{c}$ | $250.73 \pm 4.29^{c}$ | $0.34 \pm 0.13^{c}$ | $0.77 \pm 0.18^{c}$ | $0.34 \pm 0.06^{c}$ | $0.50 \pm 0.22^{c}$ |
| Unpolluted | $52.80 \pm 2.40^{c}$ | $77.48 \pm 2.32^{d}$ | $413.89 \pm 12.48^{c}$ | $21.13 \pm 0.12^{d}$ | $284.27 \pm 2.44^{d}$ | $0.04 \pm 0.00^{d}$ | $0.58 \pm 0.09^{d}$ | $0.16 \pm 0.02^{d}$ | $0.19 \pm 0.13^{d}$ |

**Values (mean $\pm$ SD of triplicate determinations) with different superscripts per column are significantly ($P<0.05$) different.**

when compared to samples from UPE. Results presented in table 8 showed that *P. mildbraedii* from UPE are excellent source of phosphorus (413.89±12.48), potassium (284.27±2.44), calcium (77.48±2.32) and magnesium (52.80±2.40). Also, the concentration of minerals in *P. mildbraedii* from PE and UPE were significantly different in all except in magnesium and phosphorus.

**DISCUSSION**

Gas flaring and other oil and gas activities for about four decades have contributed to pollution in Oguta, which have impacted on the ecosystem. Soots were seen on vegetation within the communities around the flaring site. Plants growing in such environment have over the years taken in varying doses of pollutants which invariably may affect the nutritional and chemical contents.

Our result showed that *A. esculentus* had better nutritional value than *P. mildbraedii* with respect to protein and carbohydrate contents. Also, *A. esculentus* and *P. mildbraedii* showed higher values in proximate contents (except in protein) than *A. hybridus* as reported by Nwaogu *et al.,* (2006). Carbohydrates provide energy to cells in the body, particularly to the brain, a carbohydrate dependent organ in the body. (Nelson and Cox, 2005). These vegetables can supplement the daily energy intake of humans (Bingham, 1998; Effiong *et al*., 2009). The crude fibre content, indicates that the vegetables are good sources of fibre, thus making them veritable source of roughage. The concentrations of carbohydrate were significantly reduced while ash contents were increased in plants from polluted environment when compared to plants from unpolluted environment (UPE). The reduced carbohydrate can be attributed to the effect of air pollutants as reported by Farzana (2005), in which he affirmed that it reduces photosynthesis in chloroplasts. The contents of protein, crude fiber and fat in samples from PE were lower than those from UPE but were not significantly different, which indicates that they were not adversely affected by the pollution.

The phytochemical results indicate that *A. esculentus* and *P. mildbraedii* are good sources of these beneficial chemicals. They have antioxidative, hypocholesterolemic, chemoprotective and antibacterial properties (Price *et al*., 1987; Enechi and Odonwodo, 2003; Okwu, 2004). Both vegetables are rich in alkaloids, flavonoids and tannins which indicates that they have diuretic, antispasmodic, anti-inflammatory and analgesic effects (Owoyele *et al.,* 2002; Nobre-Junior, 2007 ; Alisi *et al.,* 2011). Comparatively, *P. mildbraedii* had higher content of the phytochemicals studied. Also, significantly higher amount of phytochemicals were observed in vegetables obtained from PE. The increase can be linked to their role in oxidative stress in plants. Phytochemicals are secondary metabolite of plants, known to exhibit diverse pharmacological and biochemical effects on living organisms. It has been reported that certain phytochemicals play important role in antioxidant defense systems of vegetative plants (Ugochukwu and Babady, 2003). Pollution by gas flaring is taught to generate free radicals in surrounding environment. Thus, it is expected that plants may increase synthesis of antioxidant defense compounds.

These vegetables showed significantly high amount of vitamins especially vitamins A, $B_1$, $B_2$, $B_5$, $B_6$ and C in samples from UPE when compared to samples from PE. These vitamins are involved in intermediary metabolism of both plants and animals acting as part or whole coenzyme to some specific enzyme system and playing important role in both enzyme and non enzyme oxidative stress defense systems. The high concentrations of vitamins A and C will contribute significantly to the daily requirements in view of the reports of Murray (1998). Vitamin C maintains blood vessel flexibility and improves circulation in the arteries of smokers. The most important benefit of vitamins A and C is their involvement in free radical scavenging processes (Trumbo *et al*., 2004; Nwaogu *et al.,* 2011). These chemically active radicals are byproducts of many normal biochemical processes. Their numbers are increased by environmental assaults such as chemicals and toxins. The lower concentrations of these vitamins in samples from PE suggest an inability of the plants to synthesize these vitamins in sufficiently large amount for their metabolic functions. Oxidative stress caused by gas flaring in Oguta community can interfere with the synthetic mechanisms of the plants in the environment (Farzana, 2005).

Some of the mineral contents of *A. esculentus Moench* and *P. mildbraedii Harms* are comparable or higher than that reported for *Amaranthus hybridus* (Nwaogu *et al*., 2006) *Mucuna utilis* (Ujowundu *et al*., 2010), *Commelina nudiflora and Boerhavia diffusa* (Ujowundu *et al.,* 2008). The values obtained for the minerals indicates that the samples are good sources of mineral and are of great nutritional importance. In animals, potassium and sodium are important electrolytes. Potassium is a major intracellular cation. Sodium is involved in the regulation of acid-base equilibrium, protection against dehydration and maintenance of osmotic pressure in living system. It plays a role in the normal irritability of muscles and cell permeability (Schwart, 1975). Copper (Cu) is essential for haemoglobin synthesis, normal bone formation and the maintenance of myelin within the nervous system (Passmore and Eastwood, 1986). In animals, the manifestations of copper deficiency include; anaemia, hypo-pigmentation, defective wool keritinization, abnormal bone formation with spontaneous reproductive and heart failure (Williams, 1982). In humans, it has been established that occurrence of Cu absorption disorder in after partial gastetomycin leads to severe malnutrition just as when protein is severely deficient in the diet; as in kwashiorkor (Davies, 1972). Calcium and phosphorus are important and indispensable for the synthesis of strong bones and teeth, kidney function and cell growth (Uddoh, 1988; Brody, 1994). Phosphorus and magnesium are also important in the regulation of acid-alkaline balance in the body (Fallon, 2001).

The mineral contents, like Mg, Ca, P, S and K in vegetables from PE have significantly ($P<0.05$) reduced value compared to vegetables obtained from UPE. The release of pollutants such as oxides of sulphur and nitrogen, hydrocarbons and other volatile organic carbons can create chemical and biological conditions which may be harmful to plants and soil microorganisms. One of such conditions is the reduction in the capacity of plants to absorb cations (Wild *et al.,* 2000). Crops grown in soil with low mineral contents exhibit various forms of mineral deficiency. In plants, potassium is an essential nutrient and has an important role in the synthesis of amino acids and proteins (Malik, 1982). Ca and Mg play significant role in photosynthesis, carbohydrate and nucleic acids metabolism (Russel, 1973). The reduced content of these minerals will definitely affect these important plant processes. Lead is yet to record any physiological role in the biological system and are known to be extremely toxic even at the slightest concentration. Their presence in the samples calls for serious concern

This study has shown that *A. esculentus Moench* and *P. mildbraedii Harms* are good sources of nutrients and their consumption should be encouraged. Improved information on these plants will contribute to the awareness of their nutritive value, especially in this time of increased food insecurity. Also, gas flaring showed negative effects on these plants, which could affect animals that consume them. Similarly, the adverse health consequences on the inhabitants around the gas flare site are of great concern. Communities around such environment should be enlightened on the inherent dangers. Oil and gas industries should be compelled to upgrade their waste disposal technologies, with emphasis in gas disposal. This will reduce the detrimental effects on the health and well-being of inhabitants of Izombe in Oguta Local Government Area of Imo State.

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