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Original Research Article

Perception of the Impact of Crude Oil Exploration and Exploitation on *Vernonia Amygdalina* Used by Populations Residing in Abraka and Kokori, Delta State, Nigeria

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ABSTRACT

The exploration and exploitation of natural resources may interfere with using indigenous plants for food and medicine, including during pregnancy. However, this has not received deserving scientific attention in Nigeria, where crude oil mining is rigorously taking place in the Niger-Delta region. Using informant ethnobotanical surveys, we investigated for the first time the extent of the potential effect of crude oil exploration on *Vernonia amygdalina* (VA), the most widely used and valued plant, especially during pregnancy in Abraka and Kokori. A total of 82 participants comprising 22 Traditional Medical Practitioners (TMPs) and 60 from sundry professions in Kokori and Abraka were interviewed. Qualitative descriptive statistics were used to analyse respondents' data. Quantitative ethnobotanical indices were further used to quantify data generated from respondents. Results suggest VA is highly valued (UVI = 1.0), widely used during pregnancy (UMI = 0.98) and well cultivated in the study area (IC = 0.87). Respondents lamented that crude oil mining has negatively impacted VA (IPI = 0.596) and its efficacy (CEI = 0.354) over the years. Findings from this study calls for future in-depth scientific investigation of the potential impact of crude oil exploration and mining on medicinal plant biomass.

***Keywords*:** Ethnobotanical survey, Nigerian *Vernonia amygdalina*, Kokori/Abraka, Crude oil Spills, Quantitative Ethnobotany.

Introduction

Humans have relied on natural resources for their medicinal requirements, survival and food source since the beginning of civilisation. The extent of man's interaction with nature can make or mar a balanced ecosystem, alter plant biodiversity and thereby affect human longevity, or threaten his entire existence. Crude oil pollution is one of the outcomes of human technological advancement common to oil-rich regions of the World, such as the Nigerian Niger Delta.[1] Pollution from crude oil impacts the growth and survival of plants and may affect agricultural and ethnomedicinal practices of indigenous populations;[2] it could also result in phytochemical depletion, modification or accumulation of new phytochemicals that may be deleterious to human health, particularly plants that are most commonly used during pregnancy.[3, 4] According to WHO, 88% of all countries are estimated to use traditional medicine, such as medicinal plants for their primary healthcare needs, and this include plants most commonly taken as food and medicine during pregnancy.[5, 6] The unfavourable impact of crude oil pollution on plant species has been demonstrated in field and laboratory studies [7, 8] in a few crude oil-rich locations. However, available data is grossly inadequate to achieve a meaningful conclusion on the impact of crude oil exploration on indigenous medicinal plants. The impact has been commensurate with the pollution level, often resulting in low plant productivity, scarcity of medicinal plants and sometimes an outright extinction of threatened plants after an extended exposure period. [9] For instance, available data reported an average of 240 000 barrels of crude oil spills in the Nigerian Niger-Delta yearly.[10] However, sufficient data is required, particularly from affected populations who use these botanicals, especially those taking these plants during pregnancy, which are least accounted for in literature reports. Factors such as mechanical failure, third-party interference and entirely unknown causes have been attributed to Nigeria's high level of crude oil pollution. In particular, the ecosystem's valuable medicinal plants are the immediate victims of this human-induced environmental hazard. The medicinal plants used by these indigenous populations during pregnancy may be exposed to crude oil spills containing hydrocarbons and carcinogenic compounds like polycyclic aromatic hydrocarbons, nature-derived radioactive materials, and toxic heavy metals.[10] The unabated accumulation of these toxins in medicinal plants could pose a health risk to rural populations. Common potential health risks include toxicity-induced liver and kidney diseases. Importantly, crude oil exploration activities could release toxins that could trigger pregnancy-related complications among the rural women who depend on the affected plants.[10] In Kokori, no detailed, well-documented scientific investigation has been done beginning from a targetted investigation using ethnobotanical surveys to assess the impact of crude oil exploration on the local populations as well as the flora/plants within the environs which they depend upon. Nevertheless, these populations have continued to use these plants for food and medicine, particularly during pregnancy. Nigeria mines out about 2.5 million barrels of crude oil daily; this makes it Africa's topmost and the 6th World's largest crude oil producer.[11] In Nigeria, Delta state represents the second-largest oil-producing state, thus contributing up to 26.56% of the daily crude oil output.[12] However, not all settlements in Delta state are crude oil-rich. An example of a "crude oil-free" community in Delta state is Abraka, while Kokori is a neighbouring crude oil-rich community.[13, 14] Kokori village is one of the oil-producing settlements in the coastal region of Nigeria, where crude oil exploration activities remain constant (Figure 1.). Gas flaring and crude oil contaminating the environment, particularly the plant

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ecosystem, are prevalent. These potentially toxic contaminants pollute farmlands and forest areas where ethnomedicinal plants grow. The crude oil aerosols released into the air get to plants' foliar surfaces, which could interfere with photosynthesis and may result in wilting and even death of many of these plant species.[15] Meanwhile, some resilient plants may have also developed adaptational capacities to this hostile environment. Despite all the aforementioned potential risks these polluted plants may pose, the indigenous people, especially women, depend on the medicinal value of these plants for their primary healthcare needs. The local applications include antenatal and pregnancy-related complications. Thus, a scientific investigation using a semi-structured questionnaire to collect data from target interviewees on the plants most commonly used for food and medicine in the crude oil-rich village will represent the starting point for identifying how best to explore and exploit the natural resource without affecting living members of the ecosystem (In this case *Vernonia amygdalina*). This study was therefore carried out to document the perceived impact of crude oil exploration on medicinal plants most commonly taken as food and medicine, especially during pregnancy in Abraka and Kokori, Nigeria. The qualitative and quantitative analysis of collected data could provide the basis for further research, ultimately leading to some evidence on the level of safety of plants used in gynaecological ethnomedicine growing in the study area and how best to conserve the plant.[16] Findings may also help in policy formulation on plant conservation by the relevant authorities.

Materials and Methods

Ethics statement

The research received the approval of the Faculty of Pharmaceutical Sciences, University of Ilorin Ethical Review Committee (FPS-UERC) with ethical approval number FPS-ERC/ASN/2022/2. The informant consent form and ethnobotanical survey questionnaire used for this study are included in the supplementary section (**S1**).

Ethnographical overview and study area

Delta State is in the south-south geopolitical region of Nigeria; it covers a landmass of about 19,050 km^2, 60 % of which is land and lies approximately between 5°00' and 7°45' E and 5°00' and 7°30' N.[17] It has 25 local government areas. Geologically, the state is divided between the Central African mangroves in the coastal southwest and the Nigerian lowland forests, while a small part of the Niger Delta swamp forests is in the far south. Momentous features in Delta State are the River Niger and the Forçados River, which flow along the eastern and southern borders, respectively, while the Escravos River runs through Warri.[18] Various ethnic groups inhabit Delta State; these include Ukwuani in the east; the Anioma in the northwest; Isoko and Eruwa in the state's centre; the Ika, Ozanogogo and Olukumi in the northeast; and the Ijaw, Itsekiri, Urhobo, and Uvwie in the southwest. Economically, Delta State is mainly based on the production of crude oil and natural gas and is one of the distinctive oil-producing states in the country.[19] It is involved in agriculture on a small scale as the state has substantial oil palm, yam, cassava crops and fishing. The survey was carried out in two neighbouring settlements (Abraka and Kokori) within the Ethiope-East local government area of Delta State, Nigeria. The temperature in the area surveyed is hot and humid, and the sites are riverine, with many wetlands. The soil in the region is primarily loamy. Abraka, located 5°47′ 21.9552" N latitude and 6 °6′ 8.4492" E longitude, is a crude-oil-free community 65 metres elevation above sea level. On the other hand, Kokori (44°48′ 48.366" N, 17°29′ 29.08" E) is a crude oil-rich smaller community that suffers the consequences of oil exploration activities, including the pollution of agricultural land and medicinal plants growing on it; Kokori is located about 24 km (around 25 min drive) away from Abraka and the Eku-Agbor road links both settlements together (Figure 1.). Kokori has a total area of 196 Km ^{2}(76 sq mi).[20] Like other regions in Nigeria, Kokori and Abraka villages has only two seasons; dry and rainy. The rainy season is from March to October, while the dry season spans from November-February. Most indigenes rely on agriculture. Three popular streams in Kokori are the Iranzo stream on Orogun road, the Omwe stream on Eku road, and the Erhanaka stream on Kokori Ofuoma road.

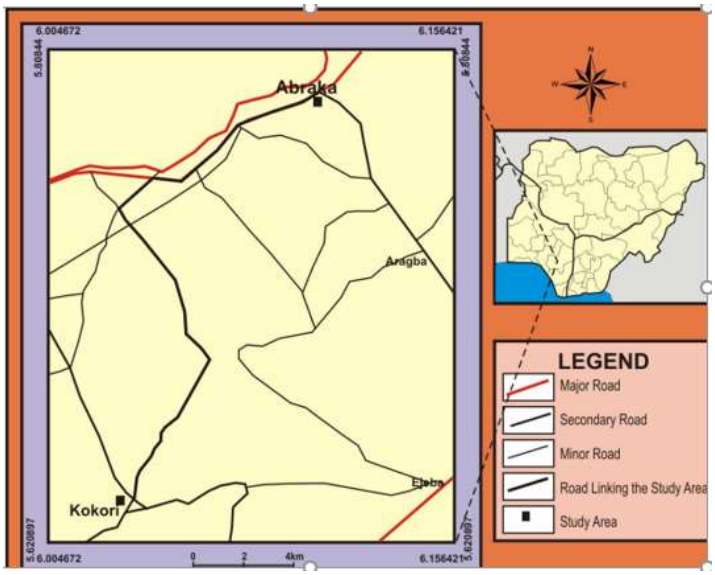

Figure 1: Map of Ethiope East Local Government Area, Delta State, Nigeria, showing study locations (Kokori crude oil-rich and Abraka crude oil-free communities). A bold black line shows the road linking the two study areas.

Questionnaire administration and data collection

In order to document the perceived impact of crude oil exploration on medicinal plants most commonly taken both as food and medicine during pregnancy in the study locations, a survey of medicinal plants commonly used during pregnancy was carried out in Kokori, the crude oil-rich community and Abraka, the crude oil-free community of Delta State, Nigeria. The method for data collection was as follows: a) surveys, b) informant preference and ethnobotanical knowledge uncovering, c) photography and inventory, d) preservation and taxonomic confirmation, e) botanical identification, and f) qualitative and quantitative ethnobotanical data analysis.[20]

A pilot study was carried out to validate our earlier work[20] which identifies *Vernonia amygdalina* (VA) as the most mentioned, valued and widely used medicinal plant during pregnancy in Nigeria. Twenty-two Traditional Medical Practitioners who practice in both villages were interviewed about the inclusion of *Vernonia amygdalina* in medicinal plant-based recipes they recommend for their patients during pregnancy. After the interviews and TMP respondents' interactive session, there was a field visit to their cultivated medicinal plant garden around their shrines. The cultivated species are the most frequently needed species used for polyherbal formulations. The follow-up visit to the medicinal plant garden encouraged an effective and efficient identification of plant species and a holistic data collection using the semi-structured questionnaire (**S2**). The commonality of mentioning *Vernonia amygdalina* among the interviewed TMPs validated the plant as the most widely used during pregnancy. Thus, ethnobotanical data on the application of VA during pregnancy was collected from the twenty-two TMPs interviewed during the pilot study and another 60 respondents from sundry professions (Table 1.) randomly interviewed from the two rural settlements. A total of 82 respondents were therefore interviewed using the Nigerian Pidgin English in this study. Some questions include how VA is used during pregnancy, the plant's source, comparative efficacy over the years and perception of the effect of crude oil mining on the efficacy/bioactivity.

Photographs of various locations, vegetation, and crude oil spill sites were taken with a "Cannon D 700" camera. After comparing the data to the literature, an inventory was created and documented.

Plant collection and Taxonomic authentication

During the ethnobotanical survey and field trip, a plant scientist (Dr. Tayo Famojuro) carried out the initial identification of plants in the field. Fresh samples were collected afterwards for voucher specimen preparation to correctly identify and authenticate collected plant

material. Following this, voucher specimen deposition (FHI 113102) was done at the Forest Herbarium Ibadan (FHI), Forestry Research Institute of Nigeria (FRIN).

Analysis of ethnobotanical data
Statistical analysis
The ethnobotanical data obtained were examined and analysed using Microsoft Office Excel® (2010, Microsoft, Redmond, WA, USA) and IBM SPSS (version 20 software, IBM Corporation, Armonk, NY, USA) software. The qualitative descriptive statistical method was used to analyse the data collected from the Traditional Medical Practitioners (TMPs) and the broader villagers from various professions, using frequencies summarised in percentages. Relevant quantitative ethnobotany (such as index of comparative efficacy, cultivation index, impact perception index of crude oil, Use-Mention index, Use-Value index and Fidelity level) was used to quantify data generated from the survey.

Use-mention principle
The Use-Mention principle originally used by Andrade-Cetto *et al*. and Attah *et al*. [21, 22] were applied here to quantify the relationship between the mentions of medicinal plants for pregnancy-related uses and the total number of respondents interviewed for pregnancy-related herbal practices. The Use-Mention index (UMI_P) was therefore applied.

$$UMI_P = \sum \frac{UP}{NP} \quad \text{..... Equation 1}$$

where 'U_P' represents the number of mentions of VA for pregnancy-related purposes, and 'N_P' number of respondents interviewed for pregnancy-based application of VA.

Use-value index (UVI)
The use-value index (UVI), initially introduced by Phillips and Gentry [23] with some modifications was applied to determine the level of importance attached to VA by the interviewed respondents as it relates to pregnancy-based applications. This index was modified to the Pregnancy-based Use-Value Index (UVI_P) to uniquely quantify generated survey data.

$$UVI_P = \sum \frac{UVM}{NM} \quad \text{..... Equation 2}$$

where 'UVM' denotes the pregnancy-based uses listed for VA, and 'N_M 'represents respondents who use VA preparations at the food-medicine interface.

Fidelity level (FL)
The Fidelity level (FL) proposed by Friedman et al. [24] was used to quantitatively analyse the percentage of respondents that produced a claim on the traditional application of *Vernonia amygdalina* (VA) for pregnancy-related complications.

$$FL = \sum \frac{NP}{n} \times 100 \quad \text{..... Equation 3}$$

where 'N_p' is the number of respondents who claim a specific use for VA related to pregnancy and 'n' is the total number of respondents using VA for any purpose.

Comparative Efficacy Index (CEI.)
In order to obtain non-laboratory based data regarding the comparative efficacy of VA over the years and now, the Comparative Efficacy Index (CEI) was introduced. This index was used to quantify VA's observed/perceived efficacy over time, especially applicable to respondents who have used VA personally or most often for family members over five years.

$$CEI = \sum \frac{En}{Ne} \quad \text{..... Equation 4}$$

E_n represents the number of respondents claiming no variation in efficacy of VA over the years, while N_e stands for the number of respondents who were interviewed under this category.
The index of cultivation (IC) of medicinal plants was introduced to quantify the level of domestication of VA; this represents the number of respondents who cultivate VA relative to the total number of respondents who use VA as a recipe during herbal practice.

$$IC = \sum \frac{Cn}{Nu} \quad \text{..... Equation 5}$$

where C_n denotes the number of respondents who cultivate VA and $N_{U.,}$ the number of respondents who use VA as a recipe.

Impact Perception Index (IPI)
The Impact Perception Index (IPI) of crude oil pollution and its resultant impact on the bioactivity and growth of VA was used to evaluate and quantify the responses of interviewed respondents regarding their perception of the impact of crude oil exploration and exploitation on the cultivated and wild medicinal plants, in particular, VA.

$$IPI = \sum \frac{In}{Ni} \quad \text{.....Equation 6}$$

where I_n is the number of respondents who confirmed the negative impact of crude oil spills on VA, and N_i is the number of respondents interviewed regarding the use of VA

Results and Discussion

Vernonia amygdalina (VA) is a small plant with deep green leaves and rough barks growing primarily in tropical Africa but domesticated in many parts of West Africa. It grows to about 6m tall, and it has a perennial pattern. VA is soft wooded, and due to its bitter taste, it is fondly referred to as bitter-leaf.[25] VA is often grown as a culinary herb in soup and food vegetables. Its richness in minerals and vitamins has made it an essential human diet alkaloids.[26] Published literature revealed that VA contains loads of phytochemicals and may be toxic at high doses.[27] More than thirty secondary metabolites belonging to different classes with varying bioactivities have been isolated and characterised from VA: sesquiterpene lactones, steroidal saponins, glycosides, flavonoids, and fatty acids and alkaloids.[26] In order to investigate how the continuous crude oil spills in Kokori affect VA, a quantitative ethnobotanical survey was performed following an interview of 82 respondents from Kokori and Abraka (Table 1).

Demographic Features of Informants
In this survey, 82 respondents (males 58.50% and females: 9.76%) were interviewed (Table 1). This study mainly targeted women and men of active reproductive age bracket, knowledgeable elderly folks and Traditional herbal practitioners who use VA as food and medicine, particularly during pregnancy (for female interviewees); far more males were interviewed due to communities with solid male dominance.
The predominant language spoken across the two villages is Urhobo, where 90% of participants from Kokori were fluent in the indigenous Urhobo language, while 56% of participants from Abraka indicated Urhobo spoken language. Interviewed respondents fall into two main occupations – farming (28.34%) and traditional medical practice (22.27%). As expected from the rural Kokori settlement, 86% of respondents from this study area were farmers, while only 6% of respondents from Abraka were farmers. Respondents' ages ranged from 22 and 85 years. The average ages of the respondents were above 60 for both males and females. The higher percentage of interviewed men against women during the study is also due to traditional healers' religious and cultural practices in preferentially passing their indigenous medicinal plant knowledge to other men. Several African studies have similarly reported more male participation in ethnobotanical surveys than women.[28, 29] Accordingly, more than 70% of interviewed respondents were men, while over 50% of the respondents were above the age of 60. The study area and many parts of rural Nigeria are male-dominated areas where the females are generally not allowed to interact directly with first-time visitors, including ethnobotanical interviewers.

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Table 1: Demographic data of respondents (n = 82) from all works of life who participated during the third face-to-face survey on the perceived impact of crude oil exploration in Kokori on *Vernonia amygdalina*.

Variable	Category	Frequency	Abraka (%)	Kokori (%)
Gender	Male	48	66.7	47.1
	Female	8	14.6	2.9
	Undeclared	26	18.8	50.0
Age	< 30	7	14.6	0.0
	31-40	4	6.3	2.9
	41-50	31	45.8	26.5
	51-60	12	10.4	20.6
	< 60	18	2.1	50.0
	Undeclared	10	20.8	0.0
Occupation	Traditional Medical Practitioners (TMPs)	22	33.3	17.6
	Farmer	28	6.3	73.5
	Civil servant	7	14.6	0.0
	Student	6	12.5	0.0
	Accountant	1	2.1	0.0
	Lecturer	3	6.3	0.0
	Data analyst	1	2.1	0.0
	Entrepreneur	1	0.0	2.9
	Medical personnel	1	0.0	2.9
	Administrative Staff	1	2.1	0.0
	Technologist	1	2.1	0.0
	Librarian	1	2.1	0.0
	Undeclared	9	16.7	2.9
Language	Urobo	58	56.3	91.2
	Igbo	2	2.1	2.9
	Others	8	16.8	0.0
	Undeclared	14	25.0	5.9
Geolocation	Abraka	41	50.0	41.5
	Kokori	34		
	Undeclared	7	8.5	
Plant Uses	Food and medicine	27	48.8	17.1
	Food only	9	7.3	14.6
	Medicine only	2	4.9	0.0
	Undeclared	44	39.0	68.3
Part Used	Whole plant	2	4.9	0.0
	Leaf	30	58.5	14.6
	Stem	3	0.0	7.3
	Seed	5	4.9	7.3
	Undeclared	42	31.7	70.7
Time of use	Anytime	27	51.2	14.6
	Morning/evening	1	2.4	0.0
	Undeclared	54	46.3	S85.4
Form/method	Cold	27	51.2	14.6
	Boiling/brewing	1	2.4	0.0
	Undeclared	54	46.3	85.4

Meanwhile, traditional caregiving in rural Nigerian villages, particularly during pregnancy, is most commonly handled by the older folks (mainly men and rarely women) in the family who go out to source required herbal remedies. Furthermore, the older male folks are more knowledgeable than younger females because they also go out to collect traditional remedies from local birth attendants and shrines of Traditional Medical Practitioners that are forbidden to women.[30] This may be responsible for a higher percentage to male participants in the study.

Respondents' application of VA and their willingness to provide data

Approximately 33% of respondents reported the application of VA at the interface of food and medicine during pregnancy, while only 13% of them use VA either as food or as medicine only. When asked about the duration or specific time of use of VA, 33% reported flexibility, mainly when applied as nutritional support during pregnancy. The plant part of VA most commonly used is the leaf (37%), while the stem is the least used part (4%) (Figure 3). Preparation of VA includes brewing in the form of tea (1%), cold extraction by squeezing (32.9), washing with salt, and preparing as bitter leaf soup (33%) (Figure 2 and 4). Some respondents were unwilling to share inherited knowledge on the medicinal value of VA and its application during pregnancy. A varying number of respondents from all categories under the study were not willing to provide data on critical aspects of the study, including the local application of VA as food and medicine (54%), duration of application (66%), a preparation method for VA (66%), plant part used (51%). This finding is consistent with earlier reports on the secrecy of traditional knowledge in Africa, fueled by the lack of trust, fear of loss, absence of long-term benefit and the absence of relevant law protecting traditional knowledge.[31, 32] This unfavourable trend could result in the total loss of valuable indigenous knowledge. However, the protection of traditional knowledge on using VA could promote equity, ensure biodiversity conservation, preserve indigenous herbal practices, and prevent biopiracy.[33, 34] The immediate potential outcome of this proposed effort will be the improved application of VA in traditional healthcare and nutrition. The custom of oral acquisition of medicinal plants or herbal knowledge has been reported in the literature.[35] Usually, the TMPs received their aboriginal medicinal knowledge directly from native healers and spiritual intuitions.

Effect of crude oil mining activities on the efficacy, accessibility and use of VA

The indigenous residents (66%) of Kokori and Abraka villages agreed that crude oil mining activities within the region profoundly affect VA biodiversity and its efficacy during pregnancy, which has consequently affected its accessibility and patronage of those who apply VA during pregnancy. Over 60% of the respondents who lamented the perceived effect of crude oil mining activities on VA were from Kokori, the crude oil-rich village. Respondents (100%) in Kokori and Abraka have resorted to VA cultivation and domestication owing to the difficulty and risk associated with sourcing VA from the wild, where crude oil mining activities have either restricted respondents from access or the spills from neighbouring oil wells have prevented the growth of VA. Participants from Kokori village are particularly affected due to their proximity which may be 1 - 3 km away from the crude oil wells. While Abraka village is up to 25 km away from the crude oil mining sites, the Traditional Medical Practitioners (TMPs) submissions in this region on the effect of petroleum exploration and mining on the efficacy and accessibility of VA are not different from their counterparts in Kokori village. However, it was observed that the cultivation and domestication of VA in the study area increased the accessibility of VA by respondents. Abraka is more urban than Kokori, which is very rural; this makes VA cultivation easier in Kokori than in Abraka, following the limited availability of agricultural lands. Hence, it may account for a higher percentage of respondents (27%) agreeing that VA has been more difficult to access in Abraka within the last ten years. Kokori village has over 40 oil wells and is believed to produce the second-best crude oil globally, owing to its low sulphur content.[36] However, like most industrial activities, crude oil exploration releases environmental hazards that are slow toxicants and are made up of various chemicals into water bodies and farmlands where ethnomedicinal plants grow; these are slowly absorbed by the plants and often take some time, maybe months to years to cause disease and death of medicinal plants.[37] As a result, few plants in Kokori may have survived this harsh extreme environment; this is forcing TMPs out of their profession, and some have moved to other villages leaving Kokori with fewer TMPs who deliver primary healthcare needs to the rural settlers.

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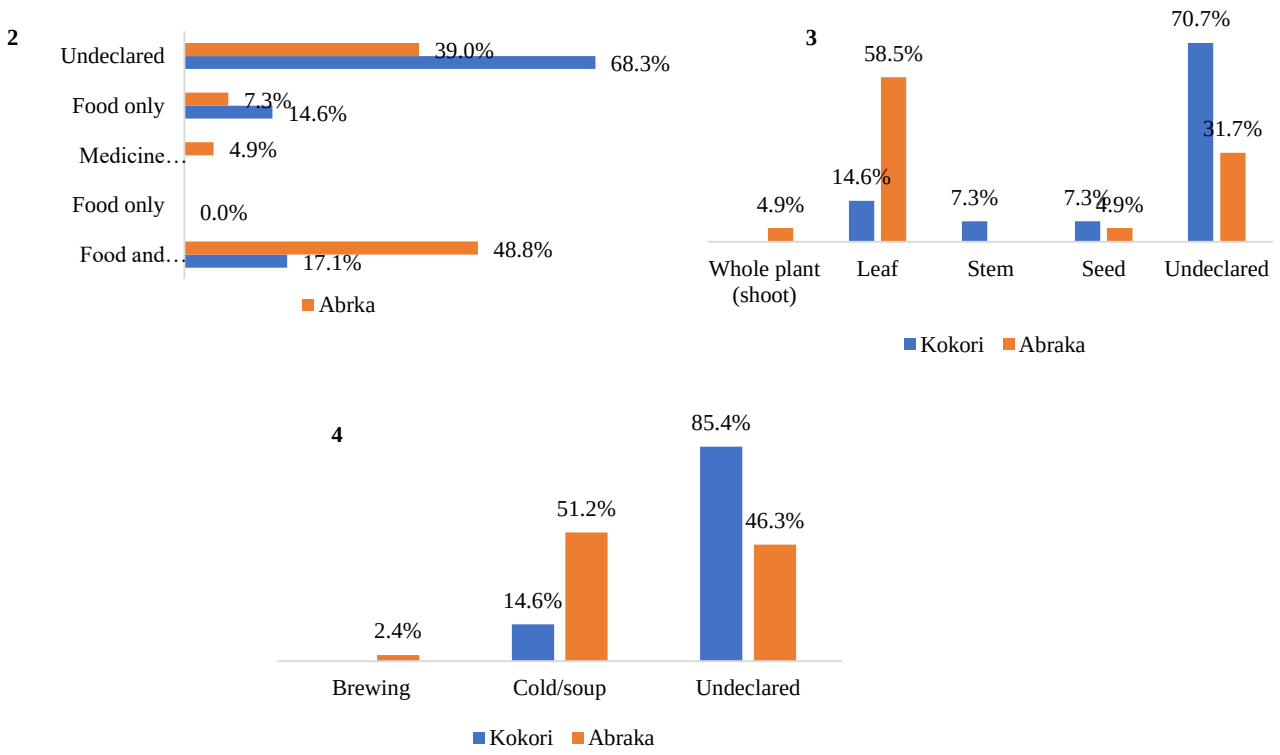

Figure 2: Method of VA application Figure 3. VA part(s) used Figure 4. Method of VA preparation. The high percentages of undeclared groups reveal an unwillingness to reveal and protect traditional knowledge

Table 2: Quantitative ethnobotanical analysis of respondents' data (n = 82) collected on the perceived impact of crude oil exploration on *Vernonia amygdalina* in Kokori

Index Name	Index	Index formula[e]	Generated data	Index analysis
Use-Mention index	UM	$\sum U_P/N_P$	81/82	0.988
Use-Value index	UV	$\sum UV_M/N_M$	81/81	1.000
The Fidelity Level	FL	$\sum N_P/n * 100$	71/82*100	86.585
Comparative Efficacy Index	CEI	$\sum E_n/N_e$	29/82	0.354
Index of cultivation	IC	$\sum C_n/N_U$	71/81	0.877
Impact Perception Index	IPI	$\sum I_n/N_i$	49/82	0.596

Nevertheless, the TMPs and residents of Kokori continue to use the surviving plants during pregnancy as food and medicine.

Quantitative ethnobotanical outcomes of Respondents' data

In addition to the qualitative analysis of respondents' data, a simple quantitative analysis was carried out to quantify the data for a numerical presentation and interpretation of respondents' data. Instead of percentages, the following indices were adopted to further simplify the outcome and facilitate a clearer description of respondents' data. The indices and result obtained include; Use-mention index (0.98), Use value index (1.0), Fidelity Level (86.59%), Comparative Efficacy Index (0.35), Index of cultivation (0.88), Impact Perception Index (0.60). The high Use Mention Index of 0.98 generated for VA is indicative of the general knowledge of the respondents on the application of VA as food and medicine, which is consistent with literature reports on the medicinal and nutritive value of VA as widely used across the tropical geographies of Africa where the plant is endemic.[38] The deliberate cultivation of VA in the study area further supports the Use Mention for VA. It means VA will continue to be used among rural populations in Kokori and Abraka, Nigeria. Beyond the VA domestication effort of the indigenous populations in the study area, deliberate plant conservation strategies geared towards protecting VA biodiversity within the study area will improve the use of VA for maximum nutritional/medicinal benefits. A Use-value Index of 1.0 was obtained from the study supporting the relative significance of VA to all interviewed respondents at the interface of food and medicine during pregnancy. This maximum Use-value index may point to the sufficient knowledge of the respondents on the medicinal and nutritional uses of VA, which they are not willing to share or declare, as observed in the high percentage of undeclared respondents' data (Figures 2, 3 and 4).

Ailments treated and plant parts used

The quantitative survey showed that VA had a fidelity level (FL) of 86.59%, implying that the majority of the respondents produced a claim that VA was used to manage pregnancy-related ailments. In crude oil-rich Kokori, TMPs use VA leaves to induce fertility in women and treat menstrual pain. The leaves are also used for breast milk enhancement in nursing mothers and to induce uterine mobility and control postpartum haemorrhage.[39,40] According to the TMPs, the time of plant part collection plays a significant role in the effectiveness of the decoction. They believe plants are awake during the day and sleep at night; this is their interpretation of the physiological and biochemical processes

within the plants. Based on this conception, TMPs believe that for some medicines to be potent, the collection of the whole plant or plant parts needed for medicinal preparations should be made before 6.00 pm. This custom cannot be dismissed as absurd due to diurnal variation in the concentration of some plant metabolites.[41] The TMPs have found that collections made at night are more efficacious than those made during the day through repetitive collections and preparations of the same medicine with plant parts collected at various times. For instance, the volatile oil-containing Siam weed (*Chromolaena odoratum* L.) is a popular plant in Nigerian ethnomedicine; it loses its oil content during the day, probably due to evaporation, in bright sunlight, but its concentration is highest from sunset to midnight.[42]

Conclusion

This work represents the first report on the indigenous people's perception of the potential impact of crude oil exploration on V*ernonia amygdalina* (VA), widely used during pregnancy in Abraka and Kokori villages of Delta state, Nigeria. While Abraka is a crude oil-free human settlement, its proximity to the crude oil-rich Kokori, where mining and gas flaring occurs, appears to have also induced a perceived negative effect on VA growing in the region. Our findings suggest that VA is valued and widely used as food and medicine within the study area, as reported in several other local settlements across Southern Nigeria. However, maximum benefit from VA may have gradually eluded the local beneficiaries due to agelong crude oil mining activities and spills polluting and reducing their access to VA. While perception alone is insufficient to conclude the extent and exact effect of crude oil mining activities on indigenous cultures' medicinal plants, it represents an ideal starting point for an in-depth laboratory-based investigation to properly validate or refute these claims. Thus, a further elaborate laboratory-based investigation could fully unveil the possible effect of petroleum mining on plant biodiversity and, by extension, human health and pregnancy. Findings from this work should trigger scientific curiosity on the possible nutritional, pharmacological and therapeutic changes in plant biomass resulting from crude oil mining in petroleum-rich regions.

Conflict of Interest

The authors declare no conflict of interest.

Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

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