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EVALUATION OF HYDROCARBON CONTAMINATION OF SELECTED WATERS OF UGWUEME AND LOKPANTA IN ENUGU NIGERIA AND ITS SPREAD MECHANISM

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Abstract

This evaluation was aimed at the determination of organic contaminants in water bodies in Ugwueme and Lokpanta in Enugu, Nigeria. The analytical study involved the sampling of water bodies both from both locations in order to conduct a comparative and qualitative study of the organic pollutants of the area..The points of sampling include; Oguta river, Lokpanta, Ugwueme spring, Seepage point at Ugwueme, Ugwueme stream and Obilagu river. The obtained result showed in mg/L; phenol (137.93 to 168.58), COD (4.07 to 9.95), BOD (11.89 to 23.99), synthetic detergent (59.6 to 74), grease (0.02 to 0.08%), pH (6.4 to 6.8), Cl (7.81 to 8.56), Br (0.19 to 0.2), asphalthene (133.2 to 178.4), ethylene (125.8 to 180.3), benzene (15.15 to 36.34), tetramethylene (77.3 to 159.1) and naphthene (10.7 to 17.2). The spread flow varied with respect to distance and altitude from the oil seep. The result revealed that the oil seep migration does not flow only at the seen point but gradually soaks into the Owelli from other parts of the contact. The close range of the organic parameter investigation confirms that the seep affects the entire mapped area, thus affecting the waters in the study area adversely showing polluted water.

Keywords: *Ugwueme-Lokpanta; organic contaminant; spread mechanism; oil seep.*

1. Introduction

It is a known fact that without water, the biosphere cannot be sustained; water is life. The water accessible to humans is basically surface and ground water. The surface waters are usually contaminated due to exposure to agents of contamination and possibly pollution. In south eastern Nigeria, there are available water bodies utilized by the local populace, such as Ugwueme and Lokpanta waters. The acessessment of the pollution level of such water is therefore necessary since its been utilized by the people. Ozoko and Onyeabor [1] in their work, considered the inorganic elements of Ugwueme surface and groundwater systems and confirmed them safe and potable. Although they recommended that the organic content ought to be checked in subsequent studies. However, research on the organic content of these water bodies is yet to be established. Ugwueme is a notable town in eastern Nigeria which experiences oil seep draining into the neighborhood streams. This was first observed by Reyment [2], in his work, he described the entire area (including Lokpanta and Ngusu and their environs) as oil soaked/oil bearing sandstone. The seep is observed at the base of Owelli Sandstone [1-2]. Ekweozor and Unomah [3] described the area as oil shale deposit of Eze-Aku Shale; having the oil soaked Owelli Sandstone overlying uncomfortably on the shales of the Eze-Aku. The total organic carbon (TOC) of the oil-soaked formation ranges from 0.07 to 1.13wt% with kerogen type 111, thus generating more gas compared to oil within optimal thermal maturity [4]. The thickness of the oil band increases from Ugwueme to Lokpanta in a S.E. direction via the exposed scarp at Ugwueme and core drilling at Lokpanta [2]. This is a low threshold for exploitation, but a high pollution threshold when exposed to the drainage of

the area. This drainage is absorbed by the soil, hence affecting both the soil and the vegetation. Okeke and Enoh [4] in their work observed the decrease in vegetation cover of Ugwueme over the years (1996 to 2016) due to hydrocarbon seepage effect on the vegetation. The Lokpanta oil shales were also enriched in some potentially hazardous trace elements; V, Cr and Ni, which according to Sonibare *et al.* [5] are not the same with what is obtainable in oil shale from other parts of the world. The study was therefore aimed at investigating the hydrocarbon content of Ugwueme and Lokpanta water bodies and their spread mechanisms to provide information on the organic contaminant levels of such useful waters.

2. The study area

2.1. Location and study extent

The study area lies within latitude $5^{0}57^{1}$N to $6^{0}02^{1}$ and longitude $7^{0}25^{1}$E to $7^{1}30^{1}$E covering an area extent of about 85.25km on a scale map of 1:25,000 (Fig 1). The study area includes Ugwueme town, Lokpanta, and fringes of Lekwesi. Lokpanta and Lekwesi are situated towards the valley of the escarpment while Ugwueme is situated on the escarpment.

The area is accessible via the Enugu–Port-Harcourt express road, Enugu, Nigeria. Ugwueme is about 2km east of the Enugu-Port-Harcourt express road, making a haphazard link to Ugwueme-Amuda-Mbala road through the Y junction along the express road. The Lokpanta and Lekwesi axis could be rightly accessed via Awgu-Orji river road which passed through Mgbidi town. It has an estimated population of about 15,000 people [6] and found at the hill /top of the Awgu escarpment, about 7.5km south of Awgu market in Awgu town which host the local government headquarters of the area. Ugwueme town is strategically located on top of the Awgu cuesta and is underlain by iron stone beds with other sedimentary facies.

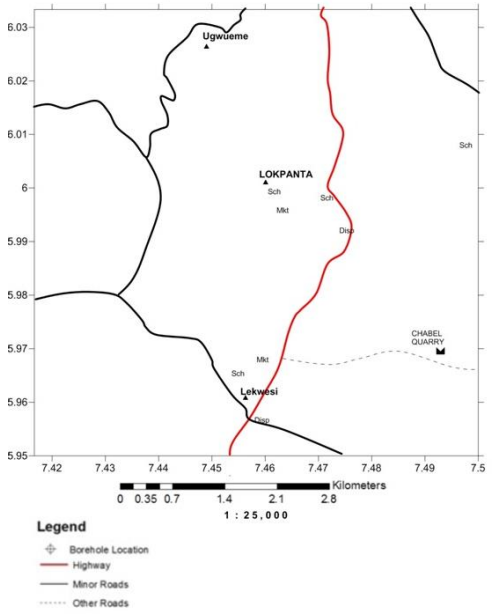

Fig.1. Accessibility map of Ugwueme-Lokpanta, Southeastern Nigeria

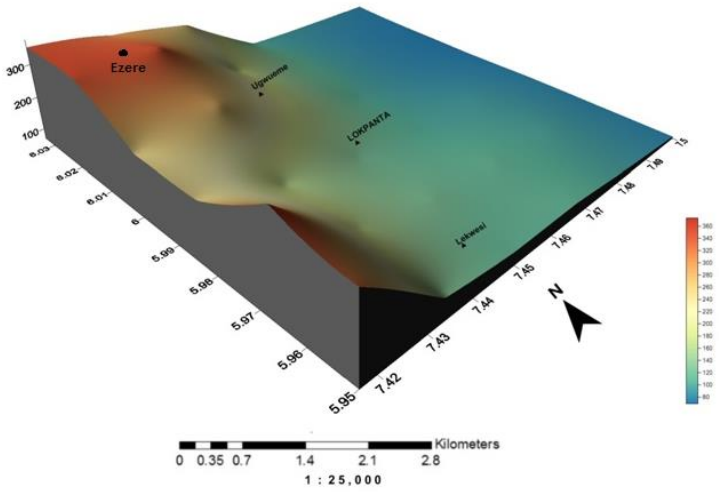

Fig. 2. Elevation map of Ugwueme-Lokpanta, Southeastern Nigeria

2.2. Physiography, climate, and vegetation

The study area has steep highlands at the escarpment area which includes Ezere, Nkwe, Mbala and Ugwueme towns of the study and also low lying plains. The low lying plains are basically found within the Lokpanta and Lekwesi axis of the map (Fig.2). The area is dominantly characterized by high, rugged and undulating topography which are in place due to the area's geomorphology and the tectonic folding and faulting of the Santonian age. The peak height is at Achara (350m, $N6^{0}0^{1}53^{11,}$ and $E7^{0}23^{1}49^{11}$) while the lowest is located around

Lekwesi (93m, N5^{0}58^{1}34.6^{11,} and E7^{0}28^{1}10.4^{11}). The major climatic conditions are the wet season (April to September) and the dry season (November to March). The average mean annual rainfall data in the area (2009 – 2015) ranges from 1750 to 2000mm [7]. The dry season which is characterized by little or no rainfall, high sunshine, and dryness is associated to the North-easterly trade wind of the Sahara. The study area is enveloped by the woodland and tall grasses of the Guinea Savanna [7]. Plants show luxuriant growth at the base of the valleys and spurs, and progressively become sparse at the escarpment. The luxuriant growth is dominated by grasses and few trees. Over the years, the vegetation in the area has supported the cultivation of crops such as cassava, vegetables, cashew and root tubers. The area is drained by several streams such as Obae, Iyiohimiri, Ngene Uhie, Ogwunnu, Ndumoku, Aguta-Lokpanta and Echie streams in a dendritic pattern, which took its source from the top of the escarpment (Fig.1). They all drain into the surface water flow of the NE-SW trending water shed created by the Awgu-Lokpanta escarpment hence, flowing westward into Igwu River, Abia state and eastward into the Ivo River in Ebonyi state.

2.3. The geology

The geology of Ugwueme and its environs is elucidated in the geologic map (Fig 2). Ugwueme is underlain by several lithological facies and four formations. These facies are; the dark gray shale, coarse grained sandstone, medium grained sandstone, heterolith sediments and white cross bedded sandstone while the formations are Awgu Shale, Owelli Sandstone, Mamu Formation and Ajalli Formation. Dark gray carbonaceous fissile shale with inclusions of sandstone and limestone cobbles are obvious along the stream sections, southeastern part of the map (Lokpanta-lekewsi). The shales are fissile, bluish grey, pyritic, calcareous, micaceous and occasionally gypsiferous [2]. The coarse grained sandstone is poorly sorted angular to sub-angular in shape with the incidence of quartz pebbles which are positively skewed. It appears dark coloured in some places. This lithologic unit is obvious around the border lines (elevations) between Ugwueme and Lokpanta maintaining a peak value (height of 300m). Ripple marks, orphiomorpha burrows and pelecipod inoceramus impressions are found within this facie [2]. This coarse grained sandstone is extended to Awgu town. There is the presence of oolitic iron stone capping the Owelli Sandstone. The medium grained sandstone is poorly sorted while the heterolith facies are assemblages of siltstone, clay, shale, mud, and ironstone. The friable unit is poorly sorted and angular to sub-angular in shape.

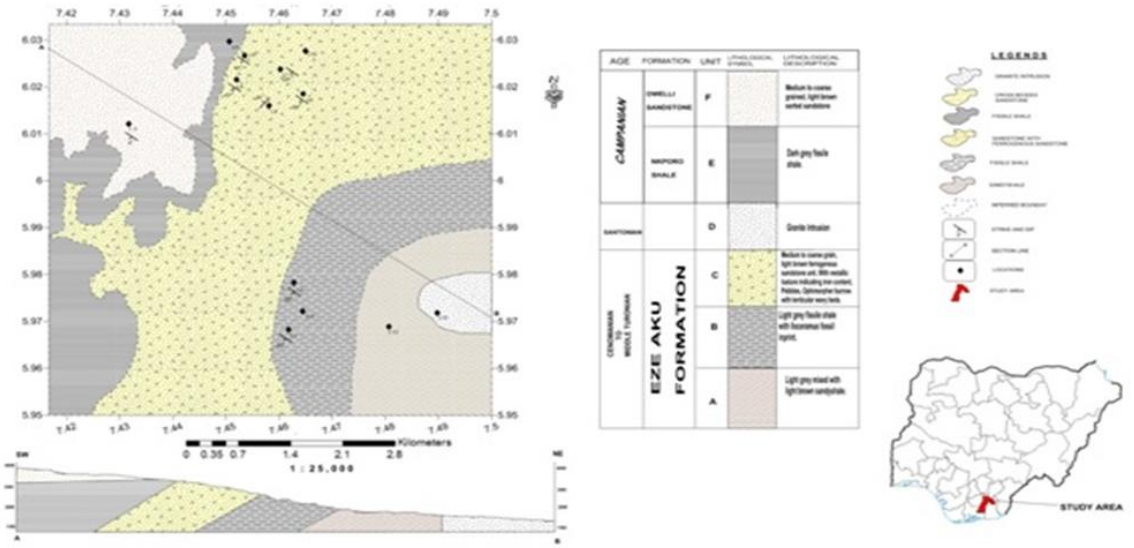

Fig.3. Geologic map of Ugwueme-Lokpanta, Southeastern Nigeria

At some points ($N6^{0}0^{1}28^{11}$ and $E7^{0}26^{1}53^{11}$), the coarse sandstone reveals resemblance of dark coloration which is attributed to oil stain. This was supported [2], according to the report, at a distance of 6km south of Awgu, oil seepage issues at the base of Owelli Sandstone was described at that point as coarse grey, the basal bed which rests uncomformably on the folded shales. This is located at the escarpment, between the Awgu Shale and Owelli Sandstone just before Lokpanta town. The oil seepage at Ugwueme is geo-referenced Lat.$06^{0}01^{1}47.5^{11}$N and Long. $07^{0}27^{1}18.7^{11}$E. The regional trend is NE-SW trend with an average dip of 8^{0} and a synclinal fold around Lokpanta. The heterogeneous facies are obvious at the Mmamo stream section. The afore mentioned facies are correlatable to the Awgu shale, Npkoro shale/Owelli sandstone, Mamu formation and Ajali formation (Fig.3) [2,8]. The study area is dissected by an NE-SW trending watershed of the Awgu-Lokpanta escarpment. This is drained by Obae, Ngene-Uhie, Ogwunnu, Oyiohimiri, Oguta, Obilagu and Echie streams which took its source from the sandstone unit at the scarp face of the escarpment and washes into the Ivo river in Ebonyi state. The Mmamo and Ngene meander through spurs and valleys into Awgu river in Mbala Isuochi Abia state.

3. Materials and methods

A desk study of the area was conducted, followed by field work and laboratory analysis of water samples for the organic pollutant. The field work involved the delineation of lithological facies and identification of the streams in order to checkmate the time/distance organic contamination of the water bodies consumed by the Locals.

Five water samples (including the water body directly receiving the seepage, (Fig.4.) were obtained with respect to topography, infiltration, recharge and discharge points. Organic parameters such as Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), asphaltthene, ethylene, benzene, tetramethylene, naphthene and organic halogens were analyzed. Nitrogen quantification was done using Micro-Kedjehl method [9]. The pH was measured with Hanna 98127. The BOD was obtained via the difference between the initial oxygen in the sample and final oxygen after 5 days of incubation at 27^{0}C. Gravimetric method [10] using n-hexane was used to measure the grease content while the synthetic detergent was obtained using methylene method, using alkyl benzene sulphonate and methylene blue in a soluble chloroform complex to determine the colour for spectrophotometric reading at a wavelength of 560nm. The Chemical Oxygen Demand (COD) was determined via incubation of K-dichromate for 6 hrs before measuring the absorbance in a standard curve at an absorbance of 520nm. All the other parameters (asphalthene, ethylene, benzene, organic halogens and tetramethylene) were prepared with the standard reagents for each, before reading the measurement in a UV-spectrophotometer (model 752p Techmel & Techmel USA) at variously recommended wavelength [11] except for chlorine which was determined using the titrimetric method with silver nitrate.

Fig.4. Oil seepage at Ugwueme

4. Results and discussion

The results obtained from the physicochemical analysis are tabulated in Table 1. The results in mg/L showed phenol ranging from 137.93 to 149.43, COD.; 4.07 to 9.95, BOD; 11.89 to 23.99, synthetic detergent; 59.6 to 74, % grease; 0.02 to 0.08, organic halogens: Cl; 7.81 to 8.56 and Br; 0.19 to 0.2, asphalthene; 143.2 to 212.5, ethylene; 125.8 to 180.3, benzene; 15.15 to 36.34, tetramethylene; 77.3 to 159.1 and naphthene; 10.7 to 15.6. The peak values reside within the seepage point and the stream it flows into except for synthetic detergent, pH, ethylene and tetramethylene an indication that the seepage occurs beyond the observed point at Ugwueme (Lat.$06^{0}01^{1}47.5^{11}$N and Long. $07^{0}27^{1}18.7^{11}$E). The Biochemical Oxygen Demand (BOD) and COD are very useful parameters in accessing the quality of water bodies. Both parameters are known to affect directly the amount of dissolved oxygen (DO) available in the water. The greater the BOD and COD the more rapidly oxygen is used up in the water, and this implies corresponding decrease in the DO value and the less oxygen available to aquatic life. The BOD values were higher than the WHO recommended limit 15mg/L except that obtained for the stream along hydrocarbon contaminated seepage point. This could have an adverse effect on aquatic lives. However, the COD values were all within the WHO recommended a range of 40 mg/L [12].

Table 1. Physicochemical analysis of the water bodies

Parameters	ROGT	UGS	HCSP	SAHCSP	ROBL
pH	6.8	6.6	6.4	6.5	6.7
Phenol	149.4	141.5	168.6	137.9	148.7
COD	4.07	5.41	9.95	6.68	4.21
BOD	23.8	20.0	21.0	11.9	23.9
Grease	0.04	0.02	0.02	0.08	0.04
Organic-Cl	8.41	8.17	7.81	8.56	8.32
Organic-Br	0.2	0.2	0.19	0.2	0.2
Ethylene	180.3	125.8	145.8	146.2	164.5
Benzene	22.7	33.3	15.15	36.63	20.4
Tetramethylene	159.1	77.3	145.6	157.6	82.4
Naphthene	15.8	14.95	10.7	17.2	15.2
Asphalthene	151.1	165.1	212.5	178.4	143.2

**ROGT=River Oguta, UGS=Ugwueme spring, HCSP=Hydrocarbon seepage point, SAHCSP= stream along hydrocarbon contaminated seepage point, ROBL= River Obilagu, All parameters are in Mg/L except pH and grease (%).*

The variation maps (Fig. 5 and 6) showed the peak points, and the spread pattern as across a given spread as mixing and dilution occur along the drainage system. A synthetic detergent which serves as a natural cleanser has a better residence in the moving waters (the rivers) hence providing a soapy cleanser function therein. The grease value is relatively low, and the pH values are close to 7.0. The required oxygen of BOD and COD are beyond the detection limits; peaks at the seepage point for COD and at River Obilagu for the BOD. The corrosive, poisonous compound (C_6H_5OH) which is usually present in tars of coal and wood exceeded the permissible limits. Fig. 5 shows an enclosure at the seepage point indicating high phenol content at the point of seepage and its progressive dilution in different water bodies. The organic halogens are closely ranged, with the point of seepage in both bromine and chloride having the lowest values (Fig. 5). Ethylene has its peak at River Oguta with an elevation of 103m and lowest at Ugwueme spring (elevation: 203m). This is an indication that the oil seep predominates the contact between the Owelli Sandstone and Agwu Shale and Owelli Sandstone and Eze-Aku Shale where it uncomformably overlies the Eze-Aku. Benzene, an aromatic hydrocarbon is found beyond the detection limits in all the samples and having its peak in the stream. The tetramethylene and naphthalene are organic compounds with simple polycyclic aromatic hydrocarbons. They are toxic to animals via putative toxicity [13].

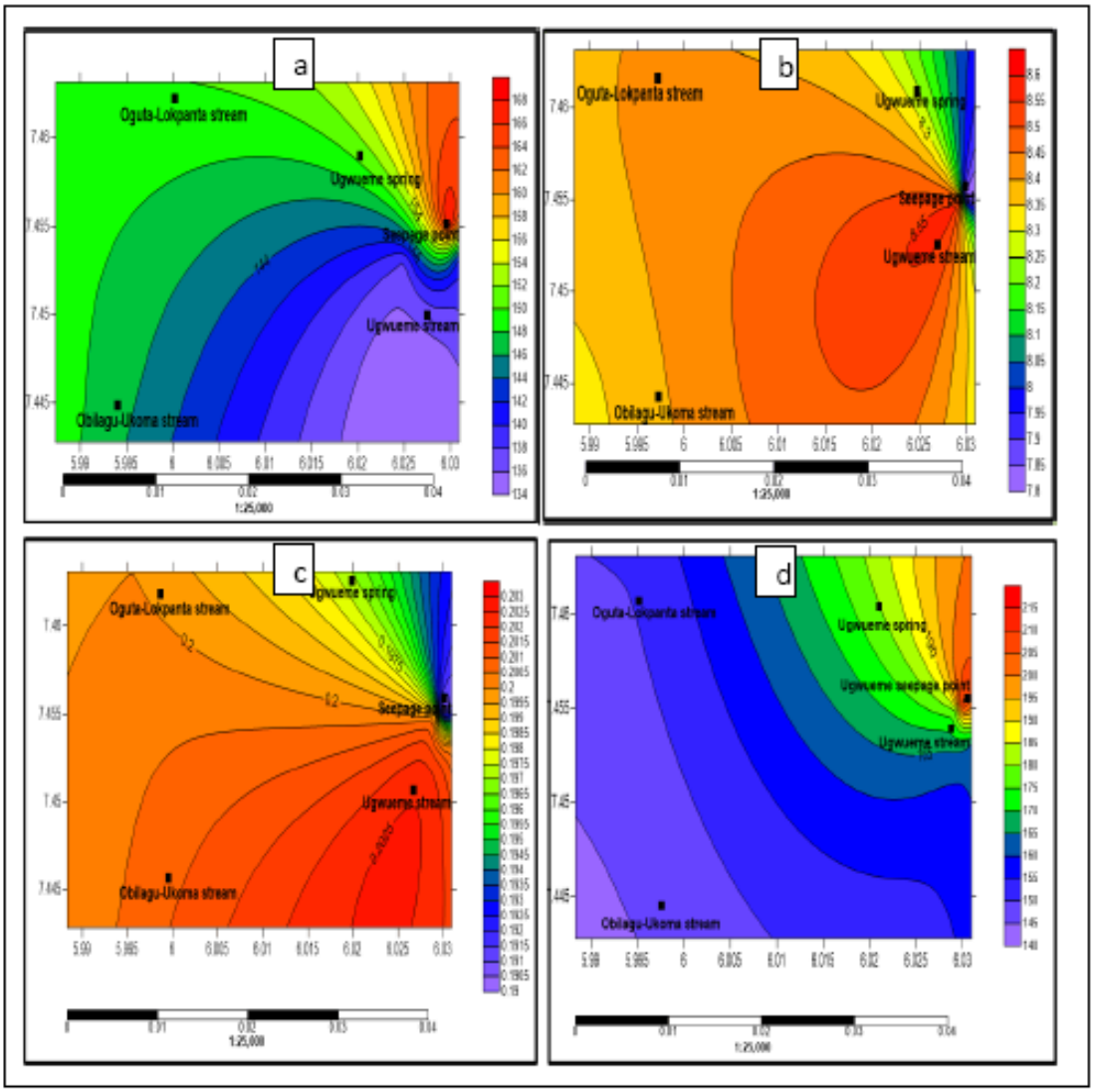

Fig 5. Spread map of (a) phenol (b) oranic chlorine (c) organic bromine (d) asphalthene

5. Conclusion

The above maps represent the interaction between sample locations and the organic contaminants. The enclosure of the map indicates a peak area from where contaminants migrate to other areas. As can be observed from the generated contour maps, the Ugwueme seepage point has most of the high concentration of all the tested hydrocarbon contaminants. Samples from the other locations; Oguta-Lokpanta, Ugwueme Stream and River Obilagu, contains organic parameters which range from trace amount to significantly high amounts. It varies in the concentration of hydrocarbon with respect to distance from seepage point and altitude. The hydrocarbon in Ugwueme stream channels is beyond the detection limit, hence affecting the biosphere through the water system, soil, and vegetation. It is recommended that further research should be conducted on the biochemical impact of this contamination on the indigene's health.

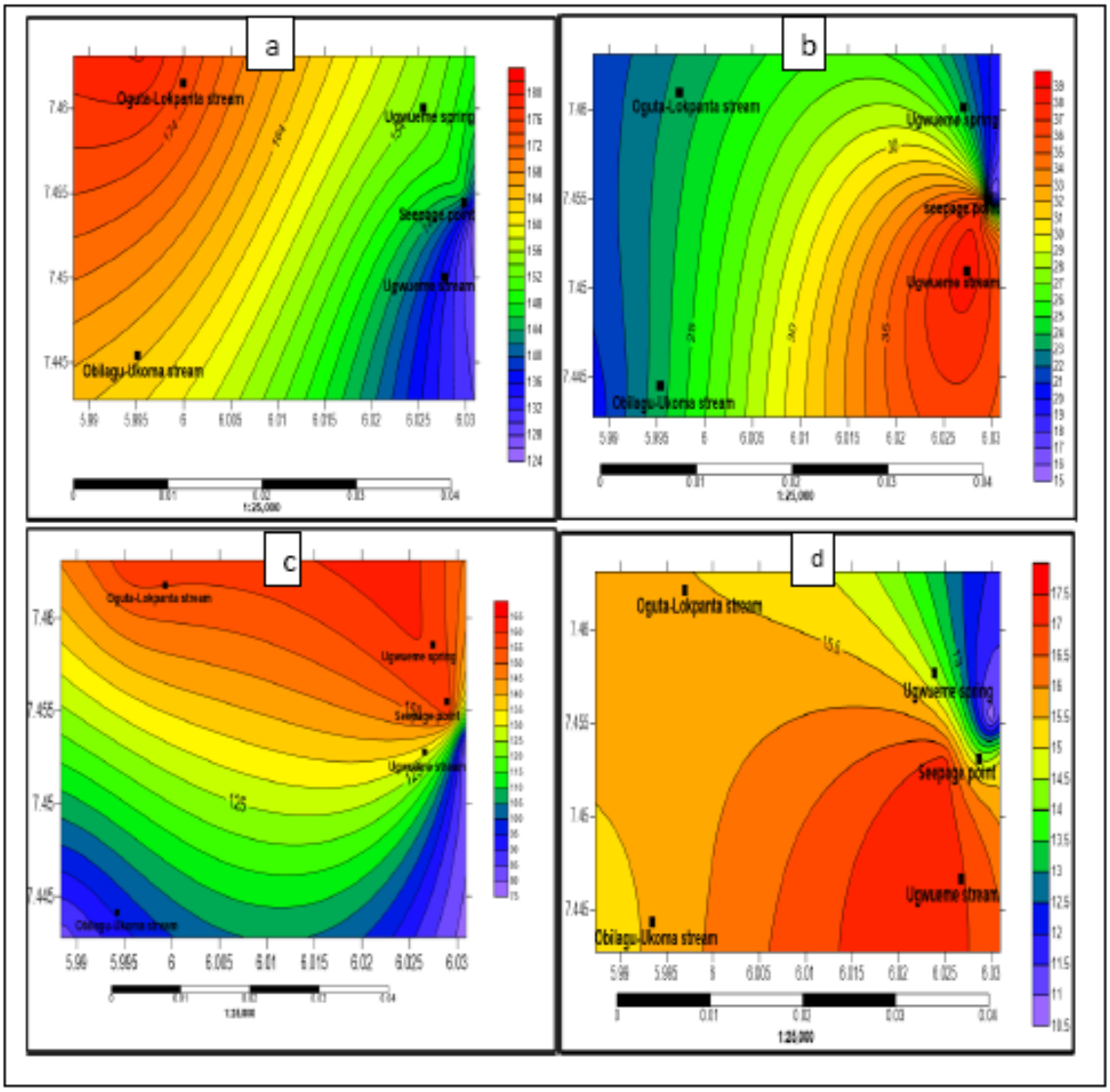

Fig 6. Spread map of (a) ethylene (b) benzene (c) tetramethylene (d) napthene

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