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Detection of Phenolic Compounds in Various Point Sources in Aba River, Nigeria

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Abstract:
Water is very important for all living organisms on earth and most of these waters in Nigeria are being polluted on a daily basis including surface water due to too much unregulated anthropogenic activities. Phenolic compounds are among the chemicals of major concern because of their persistent tendency in the environment and toxicity. The aim of this work is to detect phenolic compounds in various point sources in Aba River using GC/MS analysis. Based on the results, the water is acidic, pH ranged from 5.48 - 5.90. Thirty-two phenolic compounds were detected in all the samples although three same compounds were detected in samples 1 and 2, in other words twenty-nine different phenolic compounds were detected with their percentages ranging from 0.131-37.266. Some of these phenolic compounds are emanated from agricultural practices, effluents from pharmaceuticals, personal care products, foods, chemical, agro-chemicals industries and are very toxic therefore, this calls for a concern since their levels were above both USEPA and European Union standards

Keywords: Phenols, Aba River, pH, GC/MS analysis, point source

1. Introduction

Water is essential for life and most of the earth's surface is covered with water and is mostly affected due to pollution. The major reasons for surface water pollution include poor disposal practices of wastes into water bodies and poor guidelines policies. Such pollution includes both organic and inorganic pollutants. Some organic pollutants are highly soluble in water and can easily affect the quality of fresh water and cause severe effects on aquatic biota and humans. Also, it can easily leach into groundwater affecting drinking water. Among the organic pollutants encountered in water are phenol and its derivatives. It is important to identify and quantify phenols because of their detrimental effects on aquatic organisms as well as humans (Kalidas 2020). The presence of phenolic compounds in water can be attributed to natural and anthropogenic activities. Natural sources of phenolic compounds in water pollution include decomposition of dead plants and animals (organic matter) while anthropogenic sources include effluents from industry (chemical, petrol, and pharmaceutical), as well as domestic, agricultural and municipal activities (Schwarzbauer & Ricking 2010; Anku et al., 2017; Ekpete et al., 2023). According to Stelmaszewski (2012); Bakthavatsalam (2019); Damodhar & Prabir (2020), both phenolic and poly-phenolic compounds penetrate into surface water or ecosystems through drainage of municipal and industrial sewage widely distributed in the aquatic environment and become a threat due to their persistent and toxicity tendencies.

Many organic pollutants have been identified in water samples and some of them were classified among persistent organic pollutants (Antonijević et al., 2014; Ewa, 2017) including phenolic compounds (Ewa, 2017). They are known to be toxic and have severe short- and long-term effects on humans and animals and are introduced to the environment in a variety of ways such as waste from paper manufacturing, agriculture, pharmaceuticals, petrochemical industry, coal processing or as municipal wastes (Chimuka et al., 2007, Sun et al., 2014). International regulatory bodies have set strict discharge limits for phenols for a sustainable environment. According to Kazemi et al., (2014), EPA sets a water purity standard of less than 1 ppb for phenol in surface water. The toxicity levels usually are in the range 9-25 mg/L for both humans and aquatic life (Sharma & Bhattacharya, 2017). Phenols are used as raw materials for the production of many

aromatic compounds, such as explosives, fertilizers, paint, paint removers, textiles and drugs. Also, they are used as disinfectants and insecticides. The processes involved in the production and use of these compounds may lead to wastewater, ground water and surface water contamination. Chlorinated phenols can also form during wastewater treatment, since chlorine is added as a disinfectant (Chimuka et al., 2007) and is very toxic even at low concentrations. Prolonged oral and subcutaneous exposure to chlorophenol causes damage to the lungs, liver, kidneys and the genito-urinary tract. Exposure to wide application of phenyl phenols and bisphenols used in hospitals and households as disinfectant, in cosmetics, leather, and textile, plastic and paper industry affects the endocrine system, showing estrogenic activity (Olak et al., 2013). Long-term exposure to phenols can lead to irregular breathing, muscle weakness and respiratory arrest at lethal doses in humans while chronic exposure to phenols leads to irritation in the gastrointestinal and central nervous systems in liver, growth retardation and abnormal development in the offspring of animals (Olak et al., 2013). Many discharged effluents from industry and runoffs from cultivated agricultural lands are sources of their entrance into the water bodies (Dhielnawaaz & Priscilla, 2024). Phenolic compounds contribute to hazardous pollutants in aquatic environments and can emanate from various sources (Ekpete et al., 2023). The derivatives of phenol and polyphenol may be more harmful than the original compounds and this transformation occurs because phenols interact with physical, chemical, biological, or microbial factors in the water (Anku, 2017). Of particular concern, however, are the phenolic endocrine disrupting compounds (EDCs), which include bisphenol-A (BPA), alkylphenol ethoxylates (APEs) and their degradation products such as nonylphenol and octylphenol etc, which have been declared toxic. Generally, polyphenols are regarded as antioxidants, but can exhibit pro-oxidant characteristics by initiating an auto-oxidation process at high pH, temperature, concentration and in the presence of iron, espite their pro-oxidant effects, they are oestrogenic, immunosuppressant, carcinogenic and genotoxic (Jelena et al., 2018). It is established by studies that frequent consumption of dietary polyphenols can exert harmful effects at elevated concentrations, and this effect may worsen on interaction with other pharmacological agents (Jelena et al., 2018). Most of the analysis on water pollution in Nigeria targeted physicochemical and biological analyzes while little attention was on phenolic assessment therefore there is a need for such analysis due to overall health and environmental concerns.

Aba River is a major freshwater river located in southeastern Nigeria, flowing through Aba metropolis in Abia State. The river originates around the Osisioma Ngwa axis, including areas such as Okpu-Umuobo, Isiala-Okpu, and Mgboko-Umuette, and flows southward to join the Imo River system (Akobundu, 2012; Wokeh et al., 2023). Geographically, the river lies approximately between latitudes 5°10′30″N and 4°51′0″N and longitudes 7°19′30″E and 7°30′0″E. The total length of the Aba River from its headwaters to its confluence with the Imo River is estimated to be about 50.8 km (Wokeh et al., 2023). Aba river is used for domestic, agricultural and industrial purposes but currently the river has been overburdened with massive pollution from various sources (Okechukwu & Anthony, 2017). Numerous studies have documented a progressive decline in the water quality of the Aba River due to intense anthropogenic pressures. Aba is a highly industrialized and commercial city, and the river receives untreated effluents from industries, abattoirs, markets, and residential settlements along its banks (Uba & Ezekwe, 2020). Physicochemical analyzes of the river water have revealed elevated levels of turbidity, total dissolved solids (TDS), biological oxygen demand (BOD), and reduced dissolved oxygen (DO), all of which are indicators of organic and chemical pollution (Wokeh et al., 2023). Heavy metal contamination constitutes a major environmental concern in the Aba River. Studies have reported the presence of metals such as iron (Fe), zinc (Zn), copper (Cu), cadmium (Cd), and lead (Pb) in concentrations that often exceed World Health Organization (WHO) guideline limits for surface water (Akobundu, 2012; Uba & Ezekwe, 2020). These contaminants are largely attributed to industrial discharges, urban runoff, and indiscriminate waste disposal practices within the Aba metropolis. Microbiological assessments further indicate that the Aba River is contaminated with high loads of fecal coliforms and other pathogenic microorganisms, rendering the water unsafe for direct human consumption without treatment (Ali et al., 2021). Communities that rely on the river for domestic purposes have reported increased incidences of waterborne diseases, including diarrhea, skin infections, and gastrointestinal disorders (Ali et al., 2021).

The major activities on either bank of the Aba River that contribute to contamination and compromise water quality include hide and skin burning and related activities such as abattoir, auto mechanic activities that could expose the river to toxic pollutants, human wastes (feces, urine) and general refuse disposal sites

as well as effluents from many industries (breweries, soap factories, soft drink factories) within the area (Okechukwu & Anthony, 2017; Amadi 2012). Industries and laundry services located downstream near the river channel discharge untreated effluents into the river's flood plain without any apology and these unacceptable practices have the tendency of deteriorating water quality and this is due to the poor sanitation habits of the population and non-enforcement of sanitation laws by government officials on offenders (Amadi 2012). Overall, existing literature classifies the Aba River as moderately to heavily polluted, emphasizing the urgent need for effective waste management strategies, pollution control measures, and continuous water quality monitoring. Furthermore, some dumping sites close to the banks of the Aba River contribute to the pollution of the river. There is a need to assess the quality of the river in order to ensure its overall health. Therefore, this work detected phenolic compounds in various point sources in Aba River, Nigeria.

2. Materials and Methods

Description of the Study Area

Historically, the Aba River takes its source from Okpu-Umuobu a town, a few kilometers away from Aba town. The Aba River is a tributary of the Imo River which is the major river that passes through Aba town (Figure 1). It's situation between latitudes 5°10′30″N and 4°51′0″N of the Equator and longitudes 7°19′30″E and 7°30′0″E of the Greenwich Meridian (Figure 1) and is characterized by relatively low elevation and near flat topography which increases its runoff. The river flows in North-South direction and joins the Imo River. According to Amadi (2012), the Aba River forms the effluent discharge point for industrial and agricultural waste by the heavy and light industries that flank both sides of the river along the Aba-Port-Harcourt express way.

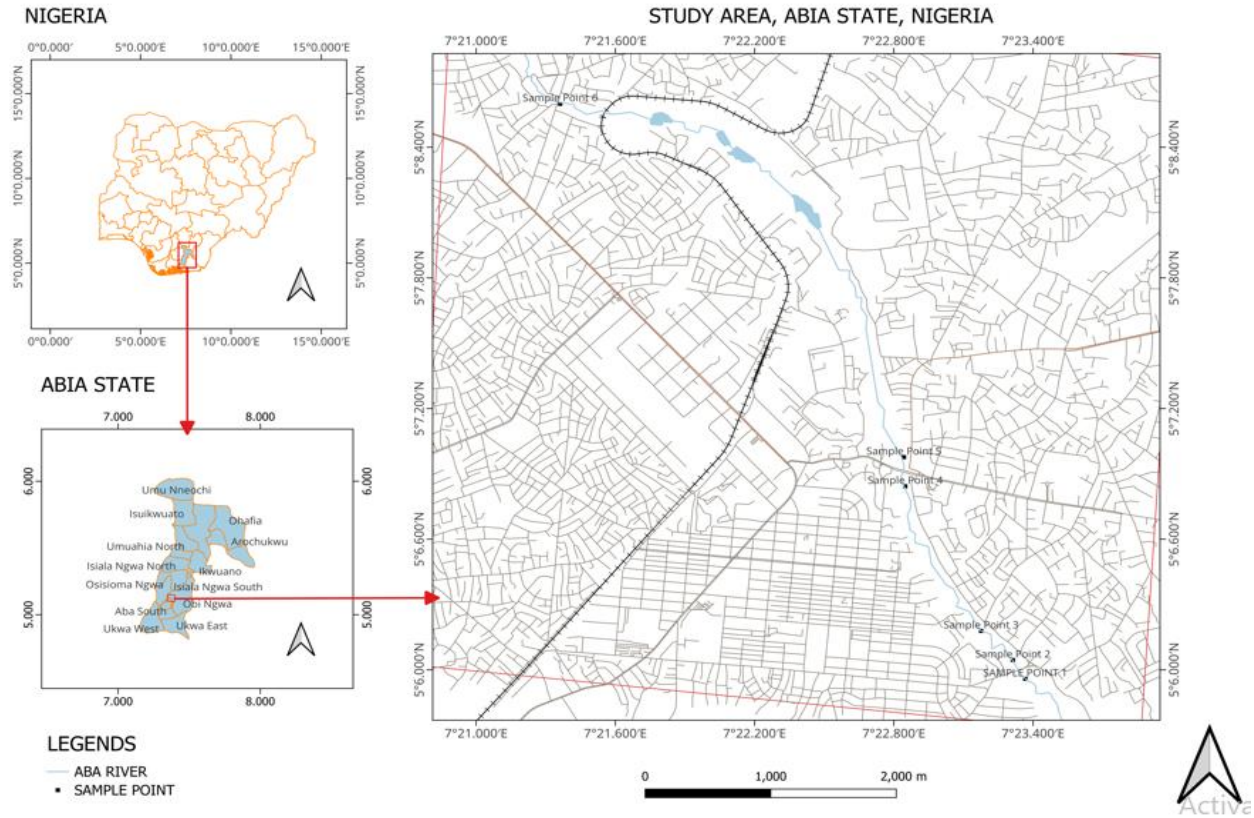

Figure 1. Location map of the study area showing Aba River, major towns and road network, and sample point's collection.

Figure 2. Refuse dumped along the river channel (Source: Amadi, 2010)

Sample Collection

Six representative samples of the Aba River were collected from six different points source of the river and were labeled as samples 1 to 6 and were sent to the laboratory for preservation before collection of the actual samples into a plastic bottle in order to ascertain if there is any phenol released by the plastics. The pH of the water samples was determined immediately after samples collection at the site.

Determination of pH of Water Sample

The pH of the representative water samples was determined using Digital pH meter LT-11. The pH meter was calibrated using appropriate buffer solutions after which the pH of the water samples was determined by dipping the electrodes of the pH meter into the water samples. All the pH analysis was done at the site.

Extraction Method for Phenolics Analysis

100ml each of the sample was measured into a separatory funnel. 50ml of an extracting solvent (dichloromethane) was added and vigorously shaken for three minutes and allowed to stand for 2 minutes. The organic layer was removed and transferred to a rotary evaporator and concentrated to about 2mL volume. This was passed through a well packed and conditioned column containing glass wool and anhydrous sodium sulphate conditioned at 40^{o}C (which is equivalent to 105^{o}F) and solvent washed prior to elution with 10ml of dichloromethane, ready for injection into the GC/MS for phenolics analysis according to Anku et al., (2017).

GC/MS Analysis

An Agilent 6890N gas chromatography equipped with an auto sampler connected to an Agilent Mass Spectrophotometric Detector was used. 1 micro-liter of each sample was injected in the pulsed spitless mode onto a 30m x 0.25mm ID DB 5MS coated fused silica column with a film thickness of 0.15 micrometer. Helium gas was used as a carrier gas and the column head pressure was maintained at 20psi to give a constant of 1ml/min. Other operating conditions were preset. The column temperature was initially held at 55℃ for 0.4min, increased to 200℃ at a rate of 25℃/mins, then to 280℃ at a rate of 8℃/mins and to a final temperature of 300℃ at a rate of 25℃/mins, held for 2mins. 1% Trimethylchlorosilane (TMCS) and N,O-

Bis(trimethylsilyl)trifluoroacetamide (BSTFA) were used in the derivatization process as catalyst and derivatization reagent. Both chemical standards and NIST library of mass spectra were used for the identification of the phenols and comparisons were made on the retention time and mass spectrum i.e. detected peaks in GC/MS were matched with known CAS numbers from reference standards.

3.Results and Discussion

The pH of the water samples

pH plays a very vital role in water assessment because of its impact on chemical and biological processes that exist in water bodies. It has a significant effect on water chemistry (Hanif et al., 2007). From the results obtained, the pH of the water samples ranged from 5.48-5.90 as shown in Table 1, indicating the acidity of the water. One of the key aspects of phenol behavior in aquatic environments is its interaction with pH, particularly under low-pH (acidic) conditions, which can influence its chemical speciation, toxicity, and environmental fate (Health Canada, 2000). Several studies have shown that phenol toxicity increases at low pH, primarily due to enhanced bioavailability of the non-ionized form. According to the Australian and New Zealand Guidelines for Fresh and Marine Water Quality, phenol exhibits greater toxicity to fish and invertebrates under acidic conditions than at neutral or alkaline pH (ANZG, 2000). Laboratory investigations on freshwater fish species such as Gambusia affinis revealed that lethal concentrations of phenol were significantly lower at pH 4.6 compared to pH 7.3, indicating increased toxicity in acidic waters (Sangli, 2021). The increased uptake of phenol at low pH results in cellular membrane damage, enzyme inhibition, and impaired respiratory functions in aquatic organisms. The combined effect of phenol presence and low pH poses serious ecological risks. Acidic conditions alone can stress aquatic organisms, disrupt metabolic processes, and alter species composition. When phenol is present, these effects are intensified due to its enhanced toxicity at low pH (Encyclopedia MDPI, 2026). Phenol contamination under acidic conditions can also suppress microbial activity, interfere with biodegradation processes, and prolong environmental persistence. These interactions complicate remediation efforts and highlight the need for pH control in wastewater treatment systems designed to remove phenolic compounds (Health Canada, 2000). According to Department of environment, science and innovation Queensland (2023), changes in pH can affect the solubility and availability of nutrients and minerals for aquatic organisms, and low pH values can lead to the release of toxic chemicals from sediments. Moreover, human activities can also alter the pH of water bodies, leading to adverse effects on aquatic life and human health. Anku et al., (2017) reported low pH on water surface with phenol contamination.

Table 1. pH values of the water samples

Samples	**1**	**2**	**3**	**4**	**5**	**6**
pH values	5.48	5.75	5.60	5.88	5.90	5.52

List of phenolic compounds identified in the samples

Blank samples indicated absence of phenols in all the plastic bottles used while the actual samples showed presence of phenols at various percentages. Figures 3 - 8 represent the gas chromatogram of samples 1-6. Each chromatogram showed various peaks of different phenols and their derivatives. This was deduced according to CAS number. Based on CAS number, samples 1-6 showed 5, 5, 4, 7, 2 and 9 phenolic compounds respectively therefore, a total of 32 phenolic compounds were identified in all the samples although three similar compounds were detected in samples 1 and 2, in other words, twenty-nine different phenolic compounds were detected as shown in Table 2 and their percentages were listed in Table 3. These include morphinan-3,1,4-diol, 4,5-epoxy- (5α)-; 3-pyridinecarboxylic acid 6-amino-; acetic acid, (2,4,5-trichlorophenoxy)-, 2-butoxypropyl ester; cis-4-Ethoxy-b-methyl-b-nitrostyrene and sparsomycin were found in sample one whereas 9H-fluoren-9-one, 2,7-bis(2-(diethylamino)ethoxy)-; glutaric acid, di(2-(pentafluorophenoxy)ethyl) ester; acetic acid, (2,4,5-trichlorophenoxy)-, 2-butoxypropyl ester; cis-4-ethoxy-b-methyl-b-nitrostyrene and sparsomycin were equally identified in sample two. 3-pyridinol, 6-methyl-; 2-Propenoic acid, 3-(4-hydroxy-3-methoxyphenyl)- (Cinnamic acid, Ferulic acid); quercetin and Aurin (p-Rosolic acid) were detected from sample 3. Sample 4 showed 1'-Biphenyl, 2,3,4,4'-tetramethoxy-5-methyl-

6'-diethylaminomethyl-; Chloropropylate; Ellagic acid; Levodopa (L-Tyrosine, 3-hydroxy-); Resveratrol, trans-; Benzoic acid, 4-hydroxy- and Nα-[N-(tert-butoxycarbonyl)methionyl]tyrosine hydrazide pollutants while phenol, 3-ethyl-, acetate and phenol, 3,4-dimethyl-, acetate were indicated in sample 5. Moreso, 4-Hexylphenyl acetate; 2-Propenoic acid, 3-[4-[(3-methyl-1-butenyl)oxy]phenyl]-, methyl ester; Benzoic acid, 2,4,6-trimethyl-, methyl ester; trans-2-Hydroxycinnamic acid, methyl ester; 2-Propenoic acid, 3-(2-hydroxyphenyl)-, (E)-; 4-Ethylcatechol; 2-Methoxy-5-methylphenol, acetate; Benzene, 1-ethoxy-2-methoxy-4-methyl- and 2-Methoxy-6-methylphenol pollutants were observed in sample 6.

The three most abundant phenols in the river include Nα-[N-(tert-butoxycarbonyl)methionyl]tyrosine hydrazide (37.266%), 3-pyridinecarboxylic acid 6-amino- (30.759%) and 2-Methoxy-6-methylphenol (26.791%). Nα-[N-(tert-butoxycarbonyl)methionyl]tyrosine hydrazide is a synthetic peptide-based compound belonging to the class of protected dipeptide hydrazides. The potential toxicity of this compound is mainly associated with the hydrazide functional group, which can interact with cellular proteins and enzymes, potentially disrupting normal metabolic pathways (Toth, 1980). Additionally, pyridoxal-dependent enzymes may be inhibited by hydrazide compounds through Schiff base formation, contributing to biochemical disturbances at high exposure levels and are equally cytotoxic and mutagenic. 3-Pyridinecarboxylic acid, 6-amino- is a synthetically produced pyridine derivative mainly used in chemical and pharmaceutical research (ChemicalBook, 2023). Its presence in the environment, is likely limited to localized contamination near chemical manufacturing or laboratory disposal sites (PubChem, 2024). Available toxicological data indicates that 6-aminonicotinic acid is not intended for human consumption and should be handled strictly as a research chemical. Safety data sheets classify it as an irritant, with potential adverse effects following skin contact, eye exposure, or inhalation (CymitQuímica, 2022). Reported hazard statements include skin irritation, serious eye irritation, and respiratory tract irritation. Studies on structurally related aminopyridine compounds suggest that pyridine derivatives may exert neurotoxic or systemic effects at high exposure levels, depending on dose and route of exposure (USEPA, 2017).

2-Methoxy-6-methylphenol also known as 6-methoxy-o-cresol or 6-methylguaiacol, is an aromatic phenolic compound that belongs to the broader class of methoxyphenols, many of which are known products of lignin degradation. One of the major natural sources of 2-methoxy-6-methylphenol is biomass burning. During the thermal decomposition of lignin—a complex biopolymer found in woody plants—various methoxyphenols are generated and released into the atmosphere. As a result, methoxyphenols such as 2-methoxy-6-methylphenol are commonly detected in wood smoke and forest fire emissions, where they serve as molecular tracers for biomass combustion (Schauer et al., 2001). Additionally, natural microbial degradation of lignin in soil and plant litter can produce low-molecular-weight phenolic compounds, including substituted methoxyphenols, which may subsequently leach into surface water and soil environments. Anthropogenic sources of 2-methoxy-6-methylphenol include industrial and domestic combustion processes, such as residential wood burning, charcoal production, and coal processing. Occupational exposure to methoxyphenols has been reported among workers in coke oven and biomass-processing industries, indicating their formation during high-temperature treatment of organic materials (Hansen et al., 2011). According to PubChem, (2024), it is harmful if swallowed and can cause skin and eye irritation. They are known to exert toxicity through protein denaturation and disruption of cellular membranes, which may result in irritation or cytotoxic effects at sufficient exposure levels (Bruce et al., 2008). While some methoxyphenols demonstrate antioxidant activity at low concentrations, this does not negate their potential toxicity when exposure is uncontrolled or prolonged. In the environment, methoxyphenols released from biomass burning contribute to particulate matter and atmospheric organic aerosols, which are associated with adverse respiratory outcomes in exposed populations (CDC, 2018). Although 2-methoxy-6-methylphenol itself is not classified as a persistent organic pollutant, its phenolic structure suggests moderate toxicity to aquatic organisms, particularly at elevated concentrations, as observed for structurally related compounds (Kumar et al., 2014).

Identification of morphinan-3,14-diol, 4,5-epoxy-, (5α)-;Sparsomycin; Quercetin; Ellargic acid; Resveratrol; Trans-2-Hydroxycinnamic acid, methyl ester; Glutaric acid, di(2-(pentafluorophenoxy) ethyl) ester and Levodopa pollutants in the samples could be attributed to the influx of effluents from the pharmaceutical industry (Atta et al., 2009; Vollmannov et al., 2024) since sparsomycin is an antibiotic and a potential antitumor agent (Atta et., al 2009), quercetin has antidiabetic, antibacterial, anti-inflammatory, and antioxidant effects, and are used to prevent hypercholesterolemia, rheumatic diseases, infections,

cardiovascular disease, cancer and Alzheimer's disease (Al Mamari, 2021; Vollmannov et al., 2024). Ellargic acid is an anti-oxidant (Landete, 2011), resveratrol is used for the prevention and treatment of several diseases including cancer, diabetes, kidney disorders, inflammation, neurodegenerative disorders, obesity, cardiac related disorders, aging and some viral infections while trans-2-hydroxycinnamic acid, methyl ester and glutaric acid, di(2-(pentafluorophenoxy)ethyl) ester are precursors to active pharmaceutical ingredients and additives (Shuchi & Mayur, 2023). Levodopa is a dopamine replacement agent for the treatment of Parkinson's disease. It is most effectively used to control bradykinetic symptoms that are apparent in Parkinson's disease (Kavita & Abdolreza, 2025). Equally quercetin and resveratrol are used in cosmetics and are associated with cosmetic waste. Trans-2-Hydroxycinnamic acid, methyl ester in the sample is associated with wastes from personal care products because it is used for the treatment of toothache, fighting of bad breath and treatment of common cold (Hameed et al., 2016). Phenol, 3-ethyl-, acetate (used in soap and detergent as fragrance; as fabric conditioners, and in perfuming) and phenol, 3,4-dimethyl-, acetate as fragrance and fragrance components (Chemical and Products Database, 2018) can also be associated with personal care product wastes. Moreover, ellargic acid is used as food supplement, quercetin is used as food additives, coloring agent and nutritional supplement (Vollmannov et al., 2024), trans-2-hydroxycinnamic acid methyl ester is used as flavoring agent in food and beverages, phenol-3-ethyl-acetate is used as flavoring agent in food, juices and wines, phenol-3,4-dimethyl-acetate is used as flavoring agent and 2-methoxy-6-methylphenol is used as flavoring agent (European Food Safety Authority, 2024) indicating that their emergence in the river could be as a result of effluents from the food industry.

Acetic acid, (2,4,5-trichlorophenoxy); 3-Pyridinecarboxylic acid, 6-amino-; Chloropropylate (Rospine) and 2-Methoxy-6-methylphenol as pollutants in the river may be associated with pesticides, insecticides and herbicides from agricultural run-off on the farmlands that surround the Aba River. According to Stella et al., (2023), a significant portion of pesticides applied in the fields enters the lakes, rivers, and oceans, by spray drift, runoff water, and drainage water. These agrochemicals used in pesticides, insecticides and herbicides are the major source of phenolic compounds to rivers, and their degradation by-products are released into the water bodies through agricultural runoff (Anku et al., 2017). The presence of glutaric acid, di(2-(pentafluorophenoxy)ethyl) ester which is a derivative of di-carboxylic acid used in the production of polyester, polyols, polyamides and nylon; 3-Pyridinol, 6-methyl-acetate (ester); Aurin (p-Rosolic acid) as dye intermediate and laboratory reagent; 4-ethylcatechol and phenol-3,4-dimethyl- acetate as intermediate solvent, corrosion inhibitor and cleaning agent in the river could be from effluents from chemical industries. Below are some of the phenols detected in the samples but their sources were unknown. These include Cis-4-ethoxy-b-methyl-b-nitrostyrene; 9H-fluorene-9-one, 2,7-bis(2-(diethylamino) ethoxy)-; 1,1'-biphenyl,2,3,4,4'-tetramethoxy-5-methyl-6'-diethylaminomethyl-; Nα-[N-(tert-butoxycarbonyl)methionyl]tyrosine hydrazide.; 4-Hexylphenyl acetate; 2-Propenoic acid, 3-[4-[(3-methyl-1-butenyl)oxy]phenyl]-, methyl ester; Benzene, 1-ethoxy-2-methoxy-4-methyl-. This could possibly be a result of the product interaction of some phenolic compounds which transform into complex phenolic compounds.

According to New Jersey Department of Health and Senior Services (2001), Acetic acid, (2,4,5-trichlorophenoxy)-, 2-butoxypropyl ester is a toxic chemical substance that when inhaled or in contact with the skin, irritates the skin and eyes, causes fatigue, headache, weakness, drowsiness, dizziness, diarrhea, abdominal pain, nausea, vomiting, convulsions, and may even lead to coma. High exposure can damage the liver, disrupt endocrine, carcinogenic, can cause abnormal heart rhythm and lead to death (New Jersey Department of Health and Senior Services Hazardous Substances, 2001). Shuchi & Mayur (2024) noted that glutaric acid, di(2-(pentafluorophenoxy)ethyl) ester can be very harmful if inhaled, swallowed, or absorbed through the skin. 3-pyridinol, 6-methyl- (synonymous to 5-Hydroxy-2-methylpyridine; 2-Methyl-5-hydroxypyridin is a corrosive and irritant chemical, harmful if swallowed, causes skin corrosion/irritation, and may lead to serious eye damage or irritation when in contact with the eye (National Center for Biotechnology Information (2025). Quercetin ie (4H-1-benzopyran-4-one, 2-(3,4-dihydroxyphenyl)-3,5,7-trihydroxy-) is a potential endocrine disrupting compound according to National Center for Biotechnology Information (2025), respiratory system and skin and very toxic to aquatic organisms. This compound can cause inflammation of the skin on contact and may accentuate any pre-existing dermatitis condition. Skins with open cuts, abraded or irritated skin should not be exposed to this compound because it may produce systemic injury with harmful effects. Chloropropylate is an organochlorine pesticide that may result in convulsions (USEPA 1999). Organochlorines are CNS stimulators that produce apprehension, excitability,

paresthesias, dizziness, headache, disorientation, and tremor progressing to stupor, coma, and convulsions in severe cases. Organochlorines may increase myocardial irritability, leading to cardiac dysrhythmias after heavy exposures. Serious complications involve seizures with resultant hypoxemia, severe metabolic acidosis, and death (USEPA 1999). This chemical is corrosive and an irritant, therefore it can lead to eye damage or irritation (Haz-Map, 2022).

Studies have shown that levodopa ie (L-Tyrosine, 3-hydroxy-) toxicity can damage neuronal cells. It induces apoptosis when it oxidizes to form free radicals. Also, dopamine, norepinephrine, and epinephrine levels can elevate in the blood when levodopa undergoes decarboxylation. The rise in catecholamines activates alpha and beta-adrenergic receptors and results in toxic effects (Kavita & Abdolreza 2025). Raw form of phenol, 3,4-dimethyl-, acetate is highly toxic by inhalation, ingestion or skin absorption. It is corrosive and extremely destructive to tissue of the mucous membranes, upper respiratory tract, eyes and skin. This chemical may cause allergic skin reaction; it is corrosive and irritant to the skin. And may also lead to serious eye damage or irritation. Symptoms of exposure to this compound may include burning sensation, coughing, wheezing, laryngitis, and shortness of breath; dizziness, stomach pain, exhaustion, and coma. It can cause headaches, nausea, and vomiting. 2-Methoxy-6-methylphenol is harmful if swallowed, and causes skin and eye irritation leading to skin corrosion or irritation and serious eye damage or eye irritation (National Center for Biotechnology Information, 2025). According to Shahoo et al., (2022), USEPA sets a permissible limit of phenol in surface water at 1 µ g L-1 while the European Union restricts the acceptable limit of phenol for surface water at 0.5 mg L-1. Based on US regulations, the levels of all the detected phenols were above these permissible limits except 1'-Biphenyl, 2,3,4,4'-tetramethoxy-5-methyl-6'-diethylaminomethyl- and chloropropylate therefore this calls for a concern.

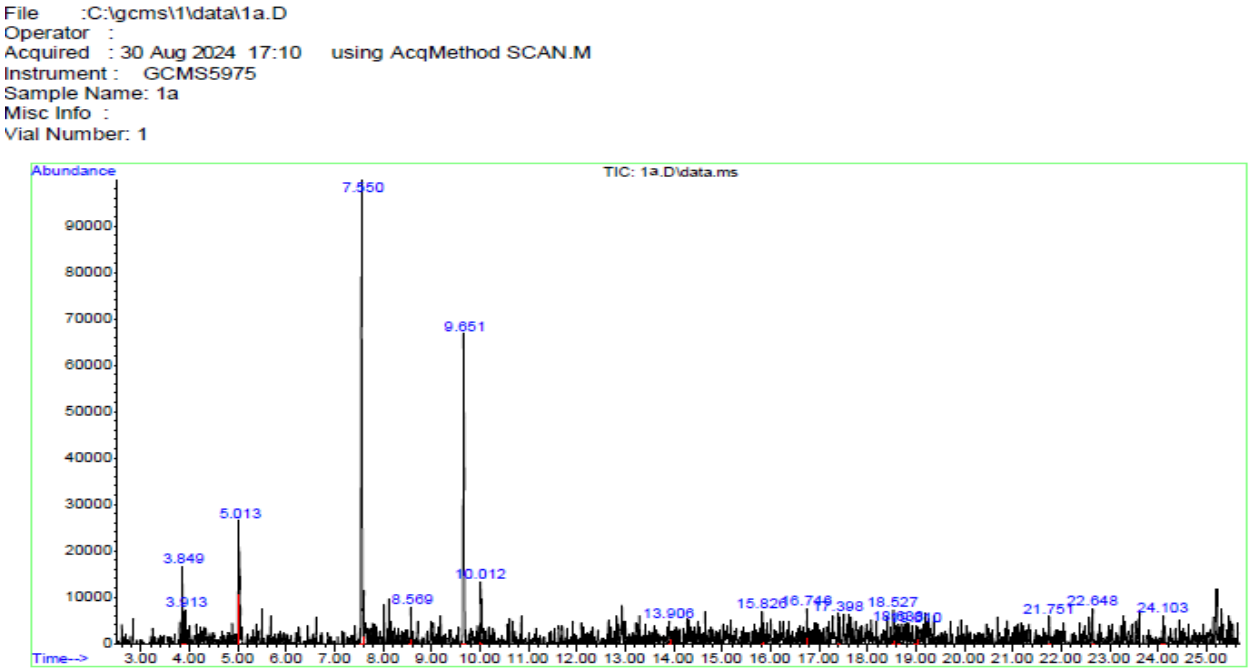

Figure 3. The Gas Chromatogram of Sample 1

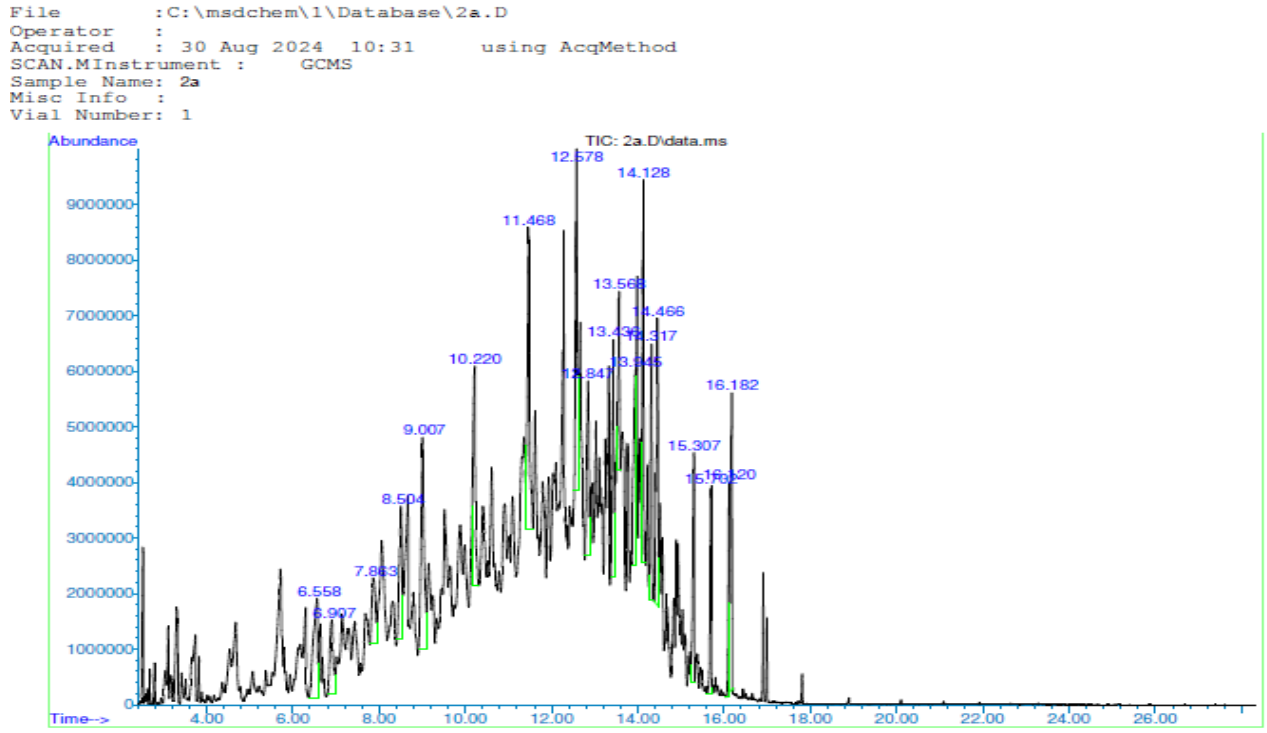

Figure 4. The Gas Chromatogram of Sample 2

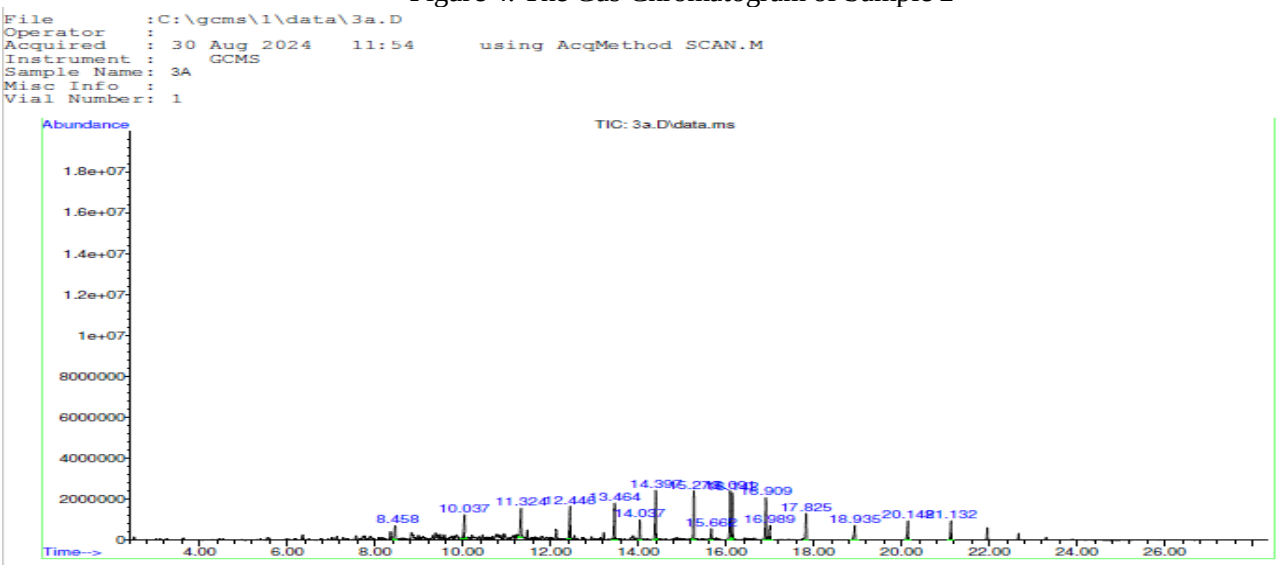

Figure 5. The Gas Chromatogram of Sample 3

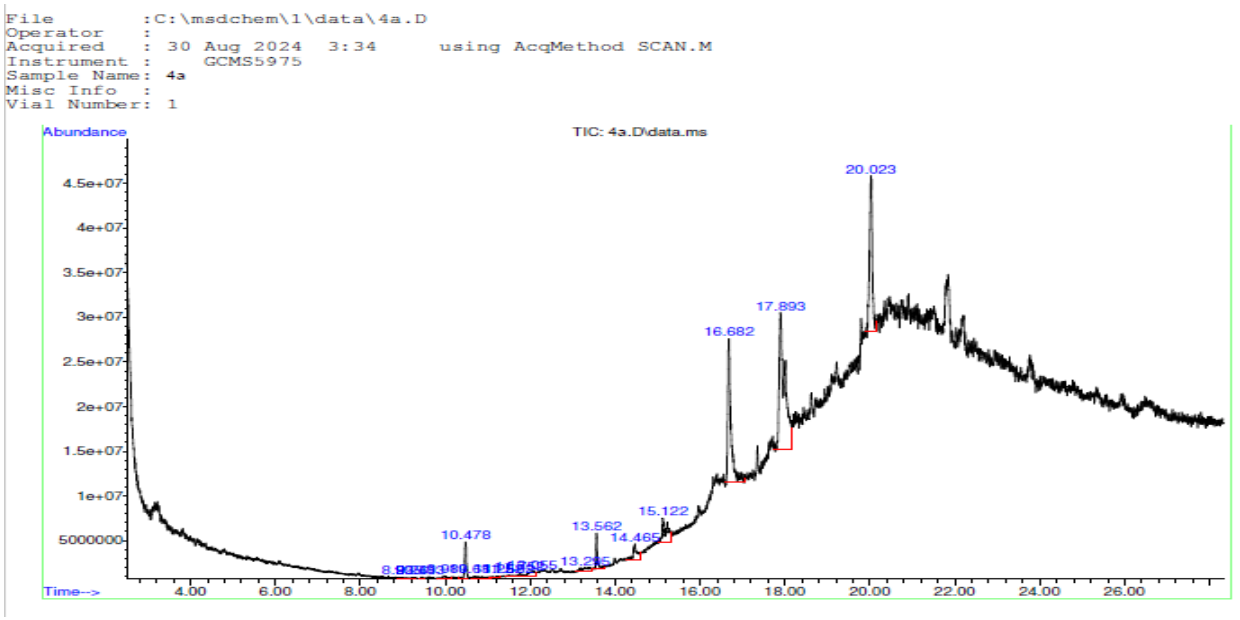

Figure 6. The Gas Chromatogram of Sample 4

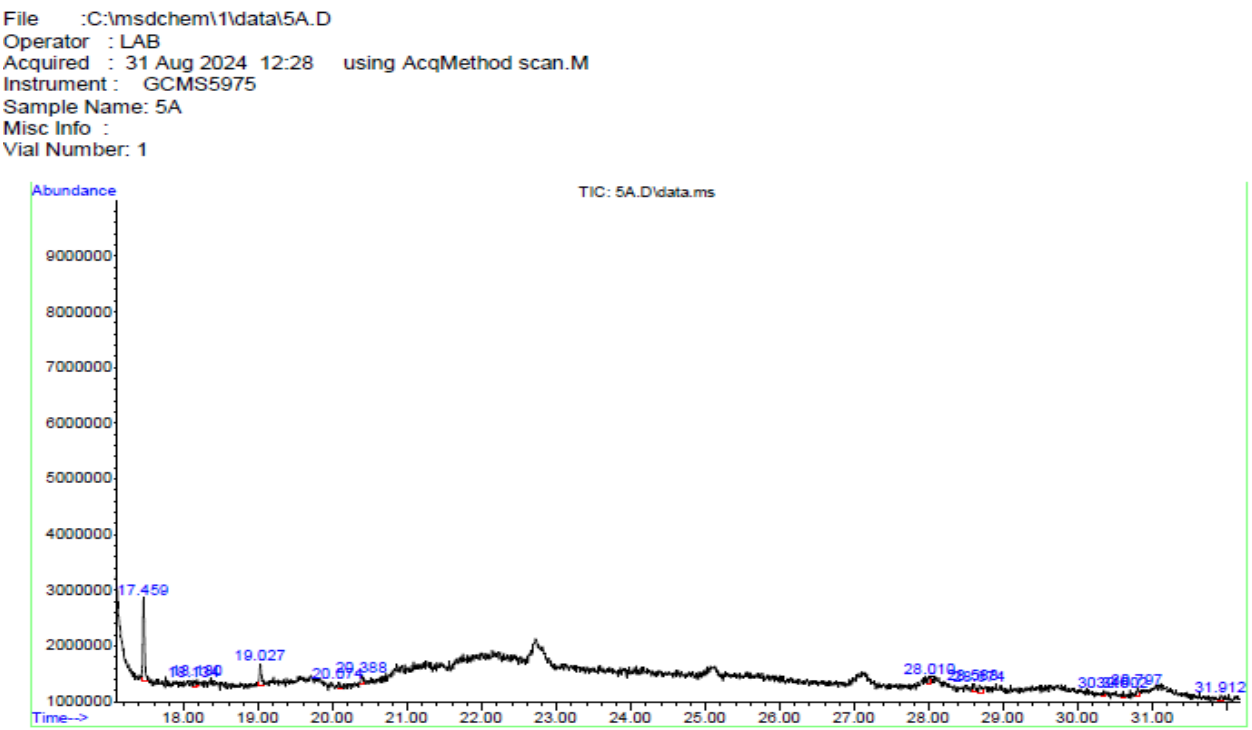

Figure 7. The Gas Chromatogram of Sample 5

File :C:\gcms\1\data\6a.D
Operator : ae
Acquired : 31 Aug 2024 9:54 using AcqMethod SCAN.M
Instrument : GCMS5975
Sample Name: 6a
Misc Info :
Vial Number: 1

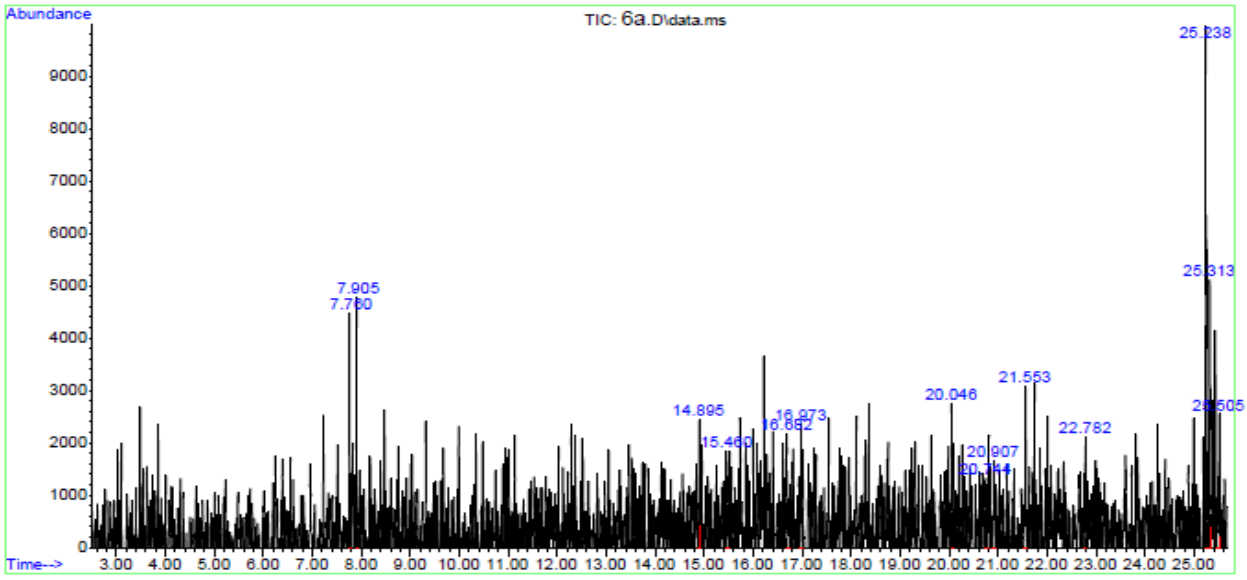

Figure 8. The Gas Chromatogram of Sample 6

Table 2: Phenols and polyphenolic compounds identified in water samples from different point sources in Aba River

Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
I.Morphinan-3,14-diol, 4,5-epoxy-, (5α)-	I. 9H-Fluoren-9-one, 2,7-bis(2-(diethylamino) ethoxy)-	I. 3-pyridinol, 6-methyl-	I. 1'-Biphenyl, 2,3,4,4'-tetramethoxy-5-methyl-6'-diethylamino methy-	I. Phenol, 3-ethyl-, acetate	I. 4-Hexylphenyl acetate
II. 3-Pyridinecarboxylic acid, 6-amino-	II. Glutaric acid, di(2-(pentafluorophenoxy)ethyl) ester	II. 2-Propenoic acid, 3-(4-hydroxy-3-methoxyphenyl)- (Cinnamic acid, Ferulic acid)	II. Chloropropylate	II. Phenol, 3,4-dimethyl-, acetate	I1. 2-Propenoic acid, 3-[4-[(3-methyl-1-butenyl)oxy]phenyl]-, methyl ester
III.Acetic acid, (2,4,5trichlorophenoxy)-,2 butoxypropyl ester	III. Acetic acid, (2,4,5-trichlorophenoxy)-, 2-butoxypropyl ester	III. Quercetin	III. Ellagic acid IV. Levodopa (L-Tyrosine, 3-hydroxy-)		III. Benzoic acid, 2,4,6-trimethyl-, methyl ester

Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
IV. cis-4-Ethoxy-b-methyl-b-nitrostyrene	IV. cis-4-Ethoxy-b-methyl-b-nitrostyrene	IV. Aurin (p-Rosolic acid)	IV. Levodopa (L-Tyrosine, 3-hydroxy-)		IV. trans-2-Hydroxycinnamic acid, methyl ester
V. Sparsomycin	V. Sparsomycin		V. Resveratrol, trans-		V. 2-Propenoic acid, 3-(2-hydroxyphenyl)-, (E)-
			VI. Benzoic acid, 4-hydroxy-		VI. 4-Ethylcatechol
			VII. Nα-[N-(tert-butoxycarbonyl)methionyl]tyrosine hydrazid		VII. 2-Methoxy-5-methylphenol, acetate
					VIII. Benzene, 1-ethoxy-2-methoxy-4-methyl-
					IX. 2-Methoxy-6-methylphenol

Table 3. Detected phenolic compounds with their percentages found in Aba river and their respective CAS numbers.

S/No	Compound	CAS Number	Percentage
1.	Morphinan-3,14-diol, 4,5-epoxy-, (5α)-	55255-50-0	3.967
2.	3-Pyridinecarboxylic acid, 6-amino-	3167-49-5	30.759
3.	Acetic acid, (2,4,5-trichlorophenoxy)-, 2-butoxypropyl ester	3084-62-6	1.541
4.	cis-4-Ethoxy-b-methyl-b-nitrostyrene	Mainlib ID 188797	1.513
5.	Sparsomycin	1404-64-4	1.631
6.	9H-Fluoren-9-one, 2,7-bis(2-(diethylamino)ethoxy)-	27591-97-5	3.322
7.	Glutaric acid, di(2-(pentafluorophenoxy)ethyl) ester	Mainlib ID: 235779	1.695
8.	3-pyridinol, 6-methyl-	1121-78-4	9.705
9.	2-Propenoic acid, 3-(4-hydroxy-3-methoxyphenyl)- (Cinnamic acid, Ferulic acid)	1135-24-6	10.522
10.	Quercetin	117-39-5	7.000
11.	Aurin (p-Rosolic acid)	603-45-2	2.531
12.	1'-Biphenyl, 2,3,4,4'-tetramethoxy-5-methyl-6'-diethylaminomethyl-	mainlib ID: 14263	0.131
13	Chloropropylate	5836-10-2	0.307
14.	Ellagic acid	476-66-4	1.259

S/No	Compound	CAS Number	Percentage
15.	Levodopa (L-Tyrosine, 3-hydroxy-)	59-92-7	2.623
16.	Resveratrol, trans-	501-36-0	3.006
17.	Benzoic acid, 4-hydroxy-	99-96-7	22.028
18.	Nα-[N-(tert-butoxycarbonyl)methionyl]tyrosine hydrazide	322682-65-5	37.266
19.	Phenol, 3-ethyl-, acetate	3056-60-8	3.168
20.	Phenol, 3,4-dimethyl-, acetate	22618-23-1	6.165
21.	4-Hexylphenyl acetate	55168-28-0	4.464
22.	2-Propenoic acid, 3-[4-[(3-methyl-1-butenyl)oxy]phenyl]-, methyl ester	55256-10-5	6.215
23.	Benzoic acid, 2,4,6-trimethyl-, methyl ester	2282-84-0	4.642
24.	trans-2-Hydroxycinnamic acid, methyl ester	mainlib ID: 88104	5.818
25.	2-Propenoic acid, 3-(2-hydroxyphenyl)-, (E)-	614-60-8	5.403
26.	4-Ethylcatechol	1124-39-6	4.375
27.	2-Methoxy-5-methylphenol, acetate	Mainlib ID: 111114	6.826
28.	Benzene, 1-ethoxy-2-methoxy-4-methyl-	33963-27-8	4.039
29.	2-Methoxy-6-methylphenol	2896-67-5	26.791

4. Conclusion

Aba city is the most highly industrialized and populated area in Abia State, Nigeria. Many anthropogenic activities have polluted the Aba River and pose threats to both aquatic life and humans. This study revealed that phenolic compounds are widely distributed in the Aba river making the water to be acidic and that Nα-[N-(tert-butoxycarbonyl) methionyl tyrosine hydrazide showed the highest abundance (37.266%). Some of the phenolic compounds identified were from agricultural activities, industrial effluents including pharmaceuticals, personal care products, foods (additives, supplements, flavouring agents), agrochemicals (pesticides, insecticides, herbicides); industrial chemicals. The levels of almost all the phenolic compounds identified were above the permissible limit of both USEPA and European Union standards hence, this calls for a concern.

References

Adamu, M. A., Mustafa, M. K., & Ruslan, N. N. (2015). Morphology of polyaniline nanotube with various level of Fe3O4 nanoparticles and their electrical conductivities by ultrasonic dispersion method. Journal of Engineering and Applied Sciences, 11(16), 9725-9729.

Akobundu, N. A. (2012). Quality assessment of Aba River using heavy metal pollution index. American Journal of Environmental Engineering, 2(1), 45–52.Stelmaszewski, A. (2012). Application of Fluorescence in Studies of Marine Petroleum Pollutants. Zeszyty Naukowe Akademii Morskiej w Gdyni(76): 74-83.

Anku, WW., Mamo, MA. & Govender, PP. (2017). Phenolic Compounds in Water: Sources, Reactivity, Toxicity and Treatment Methods.In *Phenolic Compounds—Natural Sources, Importance and Applications*; InTech Open: London, UK,. https://doi.org/10.5772/66927

Albergamo, V., Scholl´ee, JE., Schymanski, E.L., Helmus, R., Timmer, H., Hollender, J., & de Voogt, P. (2019). Nontarget screening reveals time trends of polar micropollutants in a riverbank filtration system. Environ. Sci. Technol. 53 (13), 7584–7594. https:// doi.org/10.1021/acs.est.9b01750.

Ali, A. I., Tanko, A. I., & Rilwanu, T. Y. (2021). Health impact of Aba River water on riverine communities in Aba, Abia State, Nigeria. Zaria Geographer, 28(1), 23–34.

Al Mamari, HH. (2021). Phenolic Compounds: Classification, Chemistry and Updated Techniques of Analysis and Synthesis. *Chapter Metrics Overview*. doi:10.5772/intechopen.98958

Amadi, AN. (2012). Quality Assessment of Aba River Using Heavy Metal Pollution Index, American Journal of Environmental Engineering, 2(1): 45-49

Antonijević, MD., Arsović, M., Časlavsky, J., Cvetković, V., Dabić, P. & Franko, M, (2014). Actual Contamination of the Danube and Sava Rivers at Belgrade. Journal Serbia Chemical Society. 2014; 79(9): 1169–1184.

Atta, HM., Dabour, SM. & Desoukey, SG. (2009). Sparsomycin Antibiotic Production by *Streptomyces* Sp. AZ-NIOFD1: American-Eurasian Journal of Agriculture & Environmental Sciences, 5 (3): 368-377,

Australian and New Zealand Guidelines (ANZG). (2000). *Phenol – water quality toxicant guidelines*. Australian Government.

Bakthavatsalam, A. (2019). A comparative study on growth and degradation behavior of C. pyrenoidosa on synthetic phenol and phenolic wastewater of a coal gasification plant. Journal of. Environmental Chemical Engineering 7 (3), 103079–103090. doi:10.1016/j.jece.2019.103079

Bruce, R. M., Santodonato, J., & Neal, M. W. (2008). *Summary review of the health effects associated with phenol*. U.S. Environmental Protection Agency.

Centers for Disease Control and Prevention (CDC). (2018). *Health effects of wood smoke*. CDC Environmental Health Series.

Chemical and Products Database (CPD) (2018). A resource for exposure relevant data on chemicals in consumer products, Scientific data, 5,180125. DOI:10.1038/sdata.2018.125

ChemicalBook (2023). *6-Aminonicotinic acid chemical properties and uses*. ChemicalBook Database.

Chimuka, L., Flora, N. & Anox, M. (2007). Determination of Phenols in Water Samples using Supported Liquid Membrane Extraction Probe and Liquid Chromatography with Photodiode Array Detection. South African Journal of Chemistry, 60, 102–108, http://journals.sabinet.co.za/sajchem/

CymitQuímica (2022). *Safety Data Sheet for 6-Aminonicotinic Acid*. CymitQuímica S.L.

Damodhar, G. & Prabir, G. (2020). Advanced Oxidation Processes: A Powerful Treatment Option for the Removal of Recalcitrant. http://dx.doi.org/10.5772/intechopen.90192. Advanced Oxidation Processes Applications, Trends, and Prospects. London UK Encyclopedia MDPI. (2026). *Phenol toxicity and environmental impact*.

Department of environment, science and innovation Queensland (2023). pH (water). Wetlandinfo website https://wetlandinfo.des.qld.gov.au/wetlands/ecology/components/water-chemical/ph-water

Dhielnawaaz, A. & Priscilla, GLB. (2024). 3-Methyl Thiophene-Modified Boron-Doped Diamond (BDD) Electrodes as Efficient Catalysts for Phenol Detection—A Case Study for the Detection of Gallic Acid in Three Specific Tea Types. *Foods*, *13*, 2447. https://doi.org/10.3390/foods13152447

Ekpete, OA., Nwochigoziri, EC. & Kpee, F. (2023). Assessment of Phenolic Compounds in Surface Waters from New Calabar River and Orashi River in the Niger Delta Region of Nigeria. *Journal of Applied Science & Environmental Management* 27 (9) 2029-2034.

European Food Safety Authority (EFSA), (2024). Opinion of the Scientific Panel on Food Additives, Flavourings, Processing Aids and Materials in Contact with Food Flavouring https://www.efsa.europa.eu/en

Ewa, TP. (2017) Organic Pollution of Water and Human Health. Review Paper. Health Problems of Civilization, Volume 11(1):2353-6942 Health Canada. (2000). *Priority substances list assessment report for phenol*.

Ezeigbo, HI. (1989), Groundwater quality problems in parts of Imo State, Nigeria. Journal of Mining and Geology, 25 (1), 1-9

Hameed, IH., Huda, JA. & Ghaidaa, JM. (2016). Evaluation of Antifungal and Antibacterial Activity and Analysis of Bioactive Phytochemical Compounds of Cinnamomum zeylanicum (Cinnamon bark) using Gas Chromatography-Mass Spectrometry. Oriental Journal of Chemistry. Vol. 32, No. (4): Pg. 1769-1788

Hanif, MA., Nadeem, R., Bhatti, HN., Ahmad, NR. & Ansari, TM. (2007). Ni(II) ions biosorption by *Cassia fistula* (golden shower) biomass. Journal of Hazardous Materials, 139: 345 –355.

Hansen, Å. M., Mathiesen, L., Pedersen, M., & Knudsen, L. E. (2011). Urinary metabolites of polycyclic aromatic hydrocarbons and methoxyphenols in workers exposed to biomass smoke. *International Archives of Occupational and Environmental Health*, 84, 805–814.

Haz-Map. (2022). Information on Hazardous Chemicals and Occupational Diseases https://hazmap.com

Jelena, H., Giorgio, R., Justyna, G., Natasa, S., Artur, B. & Giuseppe, G. (2018) Beneficial Effects of Polyphenols on Chronic Diseases and Ageing. In *Polyphenols: Properties, Recovery and Applications*; Elsevier Inc.: Amsterdam, The Netherlands,. https://doi.org/10.1016/B978-0-12-813572-3.00003-8.

Kalidas, M. (2020). Phenolic Compounds Contaminants in Water: A Glance: Current Trends in Civil & Structural Engineering: Mini Review. ISSN: 2643-6876. DOI: 10.33552/CTCSE.04.000593 *Washington State University, USA.*

Kavita, RG. & Abdolreza, S. (2025). Levodopa (L-Dopa). StatPearls. Treasure Island Florida: StatPearls Publishing from https://ncbi.nlm.nih.gov/books/NBK430685/

Kazemi, P., Mohammad, P., Alireza, B., Toraj, M. & Omid, B. (2014). Stability and extraction study of phenolic wastewater treatment by supported liquid membrane using tributyl phosphate and sesame oil as liquid membrane. Chemical engineering research and design 92(2): 375-383.

Kumar, V., Chopra, A. K., & Srivastava, S. (2014). Toxicity of phenolic compounds to aquatic organisms: A review. *Environmental Chemistry Letters*, 12, 229–241.

Landete, JM. (2011). Ellagitannins, ellagic acid and their derived metabolites: A review about source, metabolism, function and health. *Food Research International, 44,* 1150–1160. DOI: 10.1016/j.foodres.2011.04.027.

National Center for Biotechnology Information. (2025). PubChem Compound Summary for CID 22094, Chloropropylate. Retrieved May 8, 2025 https://pubchem.ncbi.nlm.nih.gov/compound/Chloropropylate

New Jersey Department of Health and Senior Services Hazardous Substance (NJDHSS). (2001). Fact Sheet.

Okechukwu, A. & Anthony, CCE. (2017) Quality assessment of waterside river, ogbor hill, aba 1: effect of three-point samples on some hematological parameters of wistar rats. International Journal of Hydrology 1(1): 1-5.

Olak, M., Gmurek, M. & Jacek, SM. (2013). Phenolic Compounds in the environment-occurrence and effect on living organisms. https://api.semanticscholar.org/CorpusID:55318507

PubChem (2024). *6-Aminonicotinic Acid (CID: 18496)*. National Center for Biotechnology Information.

Schauer, J. J., Kleeman, M. J., Cass, G. R. & Simoneit, B. R. T. (2001). Measurement of emissions from air pollution sources. *Environmental Science & Technology*, 35, 1716–1728.

Schwarzbauer, J. & Ricking, M. (2010), Non-tar get screening analysis of river water as compound-related base for monitoring measures. Environ Sci. Pollut. Res. Int. 17(4): 934-47.

Sharma, S. & Bhattacharya, A. (2017). Drinking Water Contamination and Treatment Techniques. Applied Water Science 7(3): 1043-1067.

Shahoo, NK., Panigrahy, N., Priadarshini, A., Sahoo, MM., Verma, AK. & Daverey, A. (2022). A comprehensive review on eco-toxicity and biodegradation of phenols: Recent progress and future outlook. Environmental Technology & Innovation, 27: 102423

Shuchi, P. & Mayur, SP. (2023). Dicarboxylic Acid, *Encyclopedia of Toxicology (Fourth Edition) Vol. 3:625-632*.

Stella, J., Estifanos, EY, Bhagwan, SC. & Feleke, Z. (2023). Determination of 2,4-dichlorophenoxyacetic acid in Water, Sediment and Soil using High Performance Liquid Chromatography. Bulletin of Chemical Society Ethiopia. 37(2), 251-263. Chemical Society of Ethiopia and The Authors Printed in Ethiopia DOI: https://dx.doi.org/10.4314/bcse.v37i2.1

Sun, R., Wang, Y., Ni, Y. & Kokot, S. (2014). Spectrophotometric Analysis of Phenols, which involves a Hemin–Graphene Hybrid Nanoparticles with Peroxidase-like Activity. *Journal of Hazardous Materials 266:* 60-67.

Uba, U. P. & Ezekwe, C. (2020). Assessment of physicochemical and microbiological quality of Aba River, Abia State, Nigeria. Nigerian Journal of Environmental Sciences, 14(2), 67–78.

U.S. Environmental Protection Agency/Office of Prevention, Pesticides, and Toxic Substances. Reigart, J.R., Roberts, J.R. Recognition and Management of Pesticide Poisonings. 5th ed. (1999). EPA Document No. EPA 73598003, and available in electronic format at: *https://www.epa.gov/pesticides/safety/healthcare, p. 58.*

USEPA. (2017). *Toxicological review of pyridine and substituted pyridines*. United States Environmental Protection Agency.

Vollmannov, A., Tatiana, B., Janette, M., Judita, L. & M. C. (2024). Review article Quercetin as one of the most abundant represented biological valuable plant components with remarkable chemoprotective effects - A review * Heliyon, 10e33342.

Wokeh, O. K., Okey-Wokeh, C. G., & Orose, E. (2023). Water quality assessment and spatial variation in Aba River water, Abia State, Nigeria. African Journal of Pure and Applied Sciences, 5(3), 112–121.