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Environmental, Health and Economic Implications of Emerging Contaminants in Nigeria Environment

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Abstract

The following were the identified and defined classes of emerging contaminants of concern (ECCs): pharmaceutical and personal care products (PPCPs), perfluorinated compounds (PFCs), plasticizers, agrochemicals, industrial additives and agents (IAAs), flame retardants (FRs), Nanoparticles (NPs), steroids and hormones, gasoline additives. From 1983 to 1990, an estimated 15,000 *metric tons* of pesticides were reported to have been imported annually. In 2016, a yearly application of about 130,000 *metric tons* of pesticides was reported for Nigeria. Nigeria's pesticides imports were worth USD128.671 in that year. Of the applied pesticides, about 85% ended in the environment as contaminants/pollutants. While few individuals in the households or neighbourhoods deal with pesticides, almost all human beings deal with PPCPs. PPCPs are taken to prevent or cure diseases and/or to sustain wellbeing. Nigeria produced 30% of its PPCPs demands while 70% imported. In 2012, 2013 and 2014, Nigeria imported PPCPs worth USD425 million, USD481 million and USD530 million respectively. In 2018, Nigeria imported PPCPs worth USD606.31 million, while the total amount of pharmaceuticals procured was USD866.16 million. Almost all the candidates of ECCs had been detected in the Nigerian environment. Untoward episodes of pesticides abuse ranging from abuse to death, have been profiled. Some of the factors responsible for these were weak regulatory instruments on accessing these pesticides, bad economy, stigmatization and lack of resilience.

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1. Introduction

Contamination can be defined as the presence of an unwanted substance in an environmental medium at low concentration with the attendance of chronic effects on the exposed environmental component(s). Pollution, on the other hand, is defined as the presence of unwanted substance in an environmental medium at high concentration with the attendance of acute effects on the exposed environmental component(s) [1].

In the United States of America, the phrase "emerging pollutants" (EPs) has been substituted by: Pollutants of emerging concern (PECs), emerging micro-pollutants (EMPs), emerging contaminants (ECs), compounds or chemicals of emerging concern (CECs) and emerging contaminants of concerns (ECCs). What is "emerging" is the awareness in both the scientific community and general public that these chemicals are being released into the environment and can be detected in water, sediment, soil, and biota [2-3]. In this study, the sources of ECCs include: agricultural, industrial, medical, pharmaceutical and whole all of the new technologies, productions, materials in-

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ventions, innovations and lots more.

Emerging Pollutants/Contaminants are substances in environmental media with evolving identification or recognition and little or no characterization or diagnosis of impacts on health and ecosystem but with hazardous or toxic tendencies. It can be broadly defined as any synthetic or naturally occurring chemical or any microorganism that is not commonly monitored in the environment but has the potential to enter the environment and cause known or suspected adverse ecological and/or human health effects [1-3]. In some cases, release of emerging chemical or microbial contaminants to the environment has likely occurred for a long time, but may not have been recognized until new methods were developed. In other cases, synthesis of new chemicals or changes in use and disposal of existing chemicals can create new sources of emerging contaminants and pollutants [3]. The USEPA [4] in its article: "Contaminants of Emerging Concern" described Emerging Contaminants as chemicals that are currently being detected or detected at levels higher than expected in the environment. Also, emerging pollutants are defined as new chemicals without regulatory status and which impact on environment and human health are poorly understood. In its understanding, NORMAN defined Emerging Contaminants (ECs) as "substances that have been detected in the environment, but which are currently not included in routine monitoring programmes at EU level and whose fate, behaviour and eco-toxicological effects are not well understood" (EU NORMAN network). Again, ECs are "those chemicals that recently have been shown to occur widely in water resources and identified as being a potential environmental or public health risk, and yet adequate data do not exist to determine their risk" (definition of the Consortium for Research and Education on Emerging Contaminants). State of Massachusetts defined Emerging pollutants as: "Hazardous materials (chemical, microbial or radiological substances) or mixtures of interest that are characterized by: a perceived or real threat to human health, public safety or environment; no currently published health standard/guideline exists or it is evolving or being re-evaluated; there is insufficient or limited available toxicological information; or, a new source, pathway, or detection limit has been discovered. Emerging contaminants may be naturally occurring or man-made." To the State of South Carolina, emerging contaminants are contaminants with a potential threat to health and environment that have no regulatory standard. In the wisdom of Chemical Material Risk Management, emerging contaminant is defined as: "chemical or material that has pathways to enter the environment and presents potential unacceptable human health or environmental risks, and either does not have regulatory peer-reviewed human health standards or the regulatory standards are evolving due to science, detection capabilities, or new pathways". "Lastly, Emerging contaminants" as defined by Susan [2] are substances not normally tested for in water quality sampling. Along with pharmaceuticals, they include a number of industrial chemicals, particularly suspected endocrine disrupting substances (EDSs) that are used in plastics, cleaning agents, personal care products like shampoos, and pesticides. These chemicals are of concern because of the risk to human health and the environment associated with their presence, frequency of occurrence or source may not be known. A Characteristic of some contaminants is that they do not need to be persistent in the environment to cause negative effects since their high transformation/removal rate is compensated by their continuous introduction into the environment. For most of the occurring emerging contaminants, risk assessment and ecotoxicological data are not available and therefore it is difficult to predict which health effects they may pose on humans, terrestrial and aquatic organisms and ecosystems [5]. ECCs are not 3 necessarily new chemicals; they may be substances that have been present in the environment for a long time but whose presence and significance are only now being recognized [6].

This article therefore reviewed the presence, concentrations and implications of ECCs in the Nigerian environment with a view to make recommendations for better economic decisions, environmental stewardship, and safer usage of ECCs.

2. Materials and Method

Relevant research publications were sourced using available search engines like Google scholar, Researchgate, Tailor and Francis online, Scopus, MPDI, Web of Science, Sage Publishing, and ScienceDirect. The key words input include emerging contaminants, environment, health, economy, Nigeria, pharmaceuticals and personal care products, herbicides, and pesticides. The articles generated were reviewed based on impacts of these contaminants on environment, human health and economy of Nigeria. Also the people in the neighbourhood were interviewed on their usage of pesticides. The information extracted was used to identify the problems and make recommendations on the way forward.

3. Emerging Contaminants

3.1. The Contaminant Candidate List (CCL) Classification Process

United States Environmental Protection Agency [4] has, for a long time now, engaged in researches to match the trend and the state of the environment with a view of being the master of it. In the quest to safeguard the health of the citizens through drinking water, USEPA developed and published an inventory (the Contaminants Candidate List, CCL) of contaminants (chemicals and microbes) in environment in 2003, especially aqua medium. Then the list has since been updated [7] to grab the trend of environmental contaminant contents and respond appropriately, through information and regulation. In preparing the list, some parameters were standardized and deployed in order to qualitatively and quantitatively assess the potential impacts of the listed Contaminant candidates. These parameters include: severity, potency, prevalence and magnitude. These parameters are employed to characterize the suspected "eco-health" and "hazardo-toxic" features of the identified substances.

The CCL is mandated to be developed by Safe Drinking Water Act (SDWA). The approach to the development of CCL

includes public participation where people were tasked to nominate substances they familiarized with and suspected to possess Potential Harmful Features (PHF) for human and ecological health. This is followed by scientific testing based on established standards. Also in 1998 EPA set up the Endocrine Disruptor Screening Program to identify substances possessing endocrine disrupting activities. The wisdom behind the program was to identify and take informed regulatory decision as ordered by the Food Quality Protection Act and the Safe Drinking Water Act Amendments passed by Congress in 1996. The program led to the release of first list in 2009, contained 67 substances as endocrine disrupting substances (EDS); and in 2010 the second list listed 134 substances was released. The state of California, USA, in 2009, did also take step to address the challenge of ECCs in the environment. The approach it adopted was public discussions and setting up of two panels (Recycled Water and Ecosystem Health) to float regulatory framework for ECCs. The Panels gathered available knowledge (information), identified knowledge gaps and made recommendations on the actions to be taken by the stakeholders. The procedure of the approach involved data collection on identified and selected ECCs, exposure threshold screening and concentration threshold setting or determination. When the threshold limit is exceeded (at maximum side of the scale), the ECC in question is listed as of high priority for regulation and monitoring [8].

There were a number of Agencies being set up by countries, regional governments and international communities to check, monitor and regulate chemicals. These include U.S. food and Drug Administration in the United States; European Medicines Evaluation Agency (EMEA) in the European Union; Health Canada in the Canada; Australian Pesticides and Veterinary Medicines in the Australia; National Agency for Food and Drug Administration and Control (NAFDAC) in Nigeria; Registration, Evaluation, Authorization and Restriction of Chemicals (REACH) regulations [9] and the Veterinary International Cooperation on Harmonization (VICH) in the US, Canada, Japan, Australia and Europe. VICH approach to listing substances as ECCs involves two phases. Phase 1 involves Use and Exposure thresholds [10]. Substances at the minimum sides of the thresholds are dropped while those on the maximum side are subjected to phase 2 testing. In the phase 2 the level of health and eco-toxicity are assessed to prioritize the ECCs [6, 11].

Human pharmaceuticals in the environment are also assessed in the EU and the US for risks, supervised by EMEA. For pharmaceuticals in aquatic environment, the threshold of 10 ng/L was established to be maximum tolerable level for aquatic environment. Pharmaceuticals that pass the threshold test are authorized for marketing. Those whose levels are above the threshold are subjected to second phase test where fate and effect screening are performed [6].

3.2. Classes of ECCs

The following were the identified and defined classes of ECCs: pharmaceutical and personal care products (PPCPs), plasticizers [12], agrochemicals, industrial additives and agents (IAAs), flame retardants (FRs), Nanoparticles (NPs), steroids and hormones, gasoline additives [13].

Pharmaceuticals are designed to cure specific ailments and ensure general wellbeing of human and livestock. Medicine and medical therapy have been with human from time immemorial. The Greeks and the Arabs of post-stone age had legacy of frontline philosophy in virtually all areas of human endeavours. However the science was at the natural levels: discovery, extraction and isolation. The 19^{th} century witnessed turn of events. Advances in technology have brought about developments in most frontiers of knowledge. Population demands, dwindling natural resources, generational consciousness... have pressurized the stakeholders to artificially imitate the natural processes, hence advanced material synthesis. Advancement in technology has occasioned changes in cultural practices: food, transportation, clothing... These emerging practices led to emerging medical complications and then emerging pharmaceuticals and therapies. Some of the classes of the pharmaceuticals include: Analgesic (ibuprofen, paracetamol, diclofenac, naproxen), antibiotic (amoxicillin, trimethoprim, Clarithromycin), antacid (ranitidine), anticonvulsant (carbamazepine), lipid lowering (e.g benzafibrate), antidiabetic (metformin), $\beta - blocker$ (atenolol, metoprolol) [12]. As mentioned, emerging needs created by population boost have led to generation of candidates of all classes of ECCs.

3.3. Volumes of ECCs dispensed by Nigeria

Of all the classes of the ECCs discussed above, agrochemicals and PPCPs were the most dispensed and in common place in Nigeria. In the period of 1983-1990, an estimate of 15,000 metric tons of pesticides was reported to have been imported annually [13, 14]. In 2016, a yearly application of about 130,000 *metric tons* of pesticides was reported for Nigeria [15]. According to FAO [16], Nigeria pesticides imports worth USD128.671 in that year [17]. Of the applied pesticides, about 85% ended in the environment as contaminants/pollutants [18].

While few individuals in the households or neighbourhoods deal with pesticides, almost all human beings deal with PPCPs. PPCPs are taken to prevent or cure diseases and/or to sustain wellbeing. Almost everyone takes PPCPs to address one of those conditions. It is therefore expected that the volume of PPCPs be more in production, circulation, application and contamination. In 2017, over one hundred and thirty pharmaceutical industries were operating in Nigeria but just nine of them listed in the stock exchange. Important also, by revenue, the average size of a Nigerian pharmaceutical firm was less than $1billion when the average size of each of the top 20 pharmaceutical companies was $21billion [19]. Nigeria produced 30% of its PPCPs demands while 70% imported [20]. In 2012, 2013 and 2014, Nigeria imported PPCPs worth of USD425 million, USD481 million and USD530 million respectively [21]. In 2018, Nigeria imported PPCPs worth of USD606.31 million [17]. The 30% locally produced pharmaceuticals in 2018 amounted to USD259.85 million. The total amount of pharmaceuticals procured for the country in 2018 was USD866.16 million. It was estimated that Nigeria pharmaceutical market grew at 13% annually. It was estimated that Nigeria used 722,892 kg of drugs in livestock production between June 2014 and Dcember 2015 [22]. It is important to point out that Nigeria has rich

flora and fauna resources which can supply huge pharmaceutical precursors and sustain world class pharmaceutical industries but lack of appropriate equipment for production, distribution and storage are the banes [23].

It was estimated that Nigeria generated about 2.5 million *tonnes* of plastic wastes per annum and these mostly ended in hydrosphere and lithosphere [24]. Nigeria accounted for 17 percent of plastic consumed in Africa between 1996 and 2017. It was estimated that Nigeria produced 2.3 million *tonnes* of plastic between 2009 and 2015 and imported 20 million *tonnes* during the same period. About 130,000 *tonnes* of plastic contents in Nigeria ended up in aquatic environment, while only 10 percent of plastic wastes in Nigeria recycled. This load invariably correlates with the amount of plasticizers in Nigeria environment [25].

3.4. Loads of ECCs in Nigeria Environment

In the years 1990 and 2009, 12,750 and 110,000 *metric tons* of pesticides contaminated or polluted Nigeria environment yearly respectively. In a period of 19 years (1990-2009), Nigeria population increased by 59,065,292 (Table 1) and the pesticides application increased by 115,000 *metric tons*. By projection the Nigeria population increase between 2010 and 2019 was 41,685,857 (a period of 9 years). This geometric increase in the population was expected to correlate with the pesticides application in Nigeria. Some of the factors that might have been responsible for the increase in the usage of pesticides were: rural-urban drift; cheaper than manual weeding; easiness; and reduction in the frequency of weeding.

Rural-urban drift: in the southern western region of Nigeria, many villagers had left their villages for cities. This drift has thinned down the rural population to aged few. This has led to change in the cultural farming practice of using peasant tools like hoes and cutlasses to do weeding. The current trend adopted in most farms now is the use of pesticides for weeding. In the time past, pesticides were only used to disinfect cash crop plants, however only few had cash crop farms unlike food crop farms. The usage of pesticides for virtually all control on farms has increased the pesticides application in many folds.

Cheaper than manual weeding: the use of pesticides is more economic friendly than engagement of human labourers. Three liters of forceup pesticide of one thousand three hundred naira (N1,300 ≡ USD3.25 as at 15/July/2020) was enough to control annual broad leaves weeds on one hectare of land. If human weeding labourer was to be engaged for the same weeding, the least cost would be thirty thousand naira (N30, 000 ≡ USD80). Pesticide usage saves about twenty six thousand naira (N26,100 ≡ USD65.25). This is a huge economic advantage among a poor population ahead of consideration for environment and/or health. The farmers have largely embraced the pesticides usage because of the economic advantage and the scarcity of human labourers. This led more pesticides application and more pesticides in the environment.

The UNODC reported that Nigeria was the epicenter of misuse and abuse of psychoactive drugs in West Africa in particular and Africa in general. Nigeria was the hub of trafficking drugs like cocaine, cannabis, opioids (tramadol, codeine and pentazocine), amphetamine, and ephedrine. Cannabis was extensively cultivated in the country. It was estimated 7.5 percent of the school children abused cannabis in Nigeria in 2016. The 25 to 39 years old Nigerians were the age bracket that mostly abused psychoactive drugs [26].

Ease of usage: weeding using pesticides is comparatively less labourious and faster to human weeding. This also has endeared pesticides usage to the farmers, thereby increased the levels of environmental pesticides.

An herbicide usage survey was conducted at Labi 2 community (L2C). L2C consist of one hundred and fifty houses. It was a semi-urban area located via Moniya, Akinyele local government, Ibadan, Oyo State, Nigeria. The residents were mixture of the middle class and the poor. 80% of the houses were not fenced and their surroundings not paved. 95% of the unfenced houses control surrounding weeds with herbicides (Figure 1). In a raining season, each of the unfenced houses applied herbicides at least three times. The active ingredient in the herbicides used was glyphosate. On the average, each house used one liter of the pesticides per a raining season (360 g of glyphosate). This amounted to $41,040\ g$ of glyphosate application in the area per a raining season. 85% of this amount was $34,884\ g$ which entered the environment as degradates, contaminants or pollutants. Due to the small size of the residential apartments, enough quantities of herbicides are always available and this leads to overdose applications.

During raining season, neighbourhoods are always overgrown which demands for weed control multiple times. The excess herbicides in the environment quickly percolate into the ground water. In Nigeria, many communities depend on well water. Many of these wells are shallowed enough for the quick reach of these herbicides. Exposure to herbicides, by populations living in the vicinity of neighbourhoods that control weeds with herbicides, through well water is very high. In a study conducted on cereals, legume, tubers, fruits and vegetables collected from Enugu state [29] aldrin, carbofuran, chlordane, heptachlor, hexacholorobenzene, lindane, dichlorodiphenyltricholoroethane... were detected but at below maximum permissible limits. Herbicides were detected at high concentrations in tissues of fishes caught in Kainji Jebba lakes [30].

Figure 1. Pictorial image of neighbourhood treated with herbicides.

According to the CIA [31], the Nigeria population below

Table 1. Population Growth and Pesticides Usage.

Year	1980[a]	1985[a]	1990[a]	2007[b]	2008[b]	2009[b]	2010[b]	2011[b]	2015[a]	2016[a]	2017[a]	2018[a]	2019[a]
Population	73,423,633	83,562,785	95,212,450	144,897,327	149,510,846	154,277,742	159,203,664	164,294,516	181,137,448	185,960,241	190,873,244	195,874,683	200,963,599
Average yearly population growth (1985-1990)	2,329,933												
Average yearly population growth (2000-2011)	4,849,297.2												
Yearly Pesticides application around 1990 (metric tons) (2000-2011)	15,000												
Yearly Pesticides application around 2000 (metric tons)	130,000												

a: worldmeter [27] b: National Bureau of Statistics [28]

poverty line was 70%. Poverty predisposed to many health complications, ranging from malnutrition diseases to life style hazards. Poverty hinders people from seeking proper medical attention and promotes quackery and abuse of pharmaceuticals in self-medication. Self-medication largely leads to wrong diagnosis and procurement of wrong drugs. This invariably leads to loads of pharmaceuticals in the environment through discard and excretion together with pharmaceutical industrial discharges, hospital waste, and deceased population left over... Ibuprofen, sulfamethoxazole, erythromycin, betasitosterol, chloramphenicol, diclofenac, naproxen, sulfadiazine, trimetoprim, amoxicillin, acetaminophen, methylparaben, artemether, triclosan, estrone, phenazone and clofifbrate had been detected in surface waters and environmental compartments [32-34]; and artemether, diclofenac and ofloxacin in portable waters [35] from Lagos; and paracetamol, ciprofloxacine, chloroquine and diclofenac in surface water and groundwater [36] from Sango-Ota, Ogun State, Nigeria. A report has it that industrial, hospital and domestic wastewaters collected from Oyo, Ogun and Lagos states South-West Nigeria contained antibiotics, estrogens and antilipid medicines. Surprisingly, some of these drugs were present at concentrations suspected to be hazardous to ecosystem [37]. In a study carried out in Lagos and Ologe lagoons in Lagos state, acetaminophen, diclofenac, amoxicillin, and methylparaben were detected. The study concluded that methyparaben was the most prevalent, followed by diclofenac while amoxicillin the least detected [33, 38]. In contrast, Anekwe *et al.* [39] who determined pharmaceuticals in surface water, ground water and drinking water from Lagos reported amoxicillin as the most prevalent in the samples. The report further stated that acetaminophen, codeine, nicotine and ibuprofen were almost equally prevalent. Season also affected environmental concentrations of naproxen, caffeine, glyburide, diclofenac, codeine and nicotine. In another study that tested Lagos surface water and some effluents, the following pharmaceuticals were detected at high environmental concentrations: Paracetamol, sulfamethoxazole, cimetidine, fexofenadine, carbamazepine, metformin, diazepam, atenolol, trimethoprim, and codeine [40].

Oil spills in Niger-Delta regions of Nigeria, which contains a range of hazardous and toxic substances, have been estimated to occur 229.9 times on the average with over 3.5 million barrels in volume [41]. In a similar report, an estimated 4,635 oil spills occurred between 1976 and 1996 in Nigeria which amounted to 2,369,470 barrels in volume [42].

Flame retardants (FRs) are ECs that are common place in Nigeria. The members of this group that have been detected in Nigeria environment include octabromodiphenyl ether, decabromodiphenyl ether and tetrabromobisphenol A. These substances were found in (electronic waste) e-waste like computer and television. Africa in general and Nigeria in particular are the dumping sites for electronic wastes with 237, 000 *tonnes* were reported for Nigeria in 2014 [43]. Also, polybrominated diphenyl ethers (PBDEs) have been detected in sediments collected in from Lagos lagoons. The work further attributed high concentration of PBDEs in the sediments to indiscriminate dumping of refuse, high industrial activities and land filling. The study concluded that deca-BDEs and penta-BDEs were the major congeners in the sediment samples [44]. Evaluation of in house dust samples from Lagos revealed the presence of halogenated FRs like PBDEs, polychlorinated biphenyls (PCBs) and hexabromocyclododecane (HBCDD) [45]. PBDEs were also detected in a stream at Obafemi Awolowo University [46] but at low concentrations. Sources of FRs in the environment include point source: production plants; and non-point sources: e-wastes, sewage sludge, land fill leaching and soil erosion, biota, dust and particulate matters and incineration [47].

Phthalate esters, classified as plasticizers under ECCs, were reported to present in sachet water from Delta state, though below threshold level. The presence of these molecules in the sampled water was attributed to nylon used for packaging [48]. The level of phthalates detected in Orogodo river, Delta state, by Edjere *et al.* [49] was 3.29 $\mu g/L$. This amount was higher than $3\mu g/L$ maximum permissible level for some aquatic organisms set by United States Environmental Protection Agency (USEPA). This high concentration of plasticizers in the river was blamed on indiscriminate dumping of solid wastes. A test conducted on surface sediment samples collected from Cross River system revealed presence of phthalates at levels that called for environmental action while discharged of untreated effluents and burning of plastic materials were cited as factors responsible for this condition [50].

3.5. Environmental and Health Implications of ECCs

The properties of glyphosate, the active ingredient in most pesticides common among users in Nigeria, were presented in Table 2. From Table 2, it could be deduced that glyphosate was relatively soluble in water. This raises the possibility of excess of it in the environment dissolves in water, percolates into the

groundwater and contaminates/pollutes it. Decomposition temperature of 215 ^oC would be difficult to attain in the natural environment and this explains why it is stable. Fairly stability status would also make glyphosate persist in the environment. The carboxylic group ($-COOH$) and the amino group ($-NH$) impacted glyphosate with zwitterions character. $-COO-$ will form in basic medium and $-HN+$ in acidic medium. The zwitterions condition, the lone pairs of electrons on oxygen and nitrogen and the presence of high percentage of oxygen atoms suggested high environmental activities (oxidative tendency) of glyphosate.

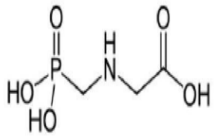

Figure 2. The Chemical Structure of Glyphosate [51].

Table 2. Properties of glyphosate [52].

Common Name	Glyphosate
IUPAC Name	2-(phosphonomethylamino) acetic acid
Molecular Formula	$HOOCCH_2NHCH_2PO(OH)_2$
UN Number	3077
Decomposition	215 ^oC
Solubility	10.5 g/L at 20 ^oC
Stability	Stable at pH 3, 4, 5, 6, 9 at 50 ^oC
pKa	2.0; 2.6; 5.6; 10.6
Metabolite Formation	aminomethyl phosphonic acid (AMPA) (0.3%)
Hazard Statement	Toxic

However it was reported that glyphosate strongly adsorbed to the soil with half life of two months [53] and broke down by microorganisms [54]. Glyphosate obstructed homeostasis [55, 56]. Untoward episodes of pesticides deaths, ranging from abuse to accident, have been profiled. Some of the factors responsible for these were abundant availability of and ease of accessing these pesticides, bad economy, stigmatization, lack of resilience... Many Nigerians were reported to have committed suicide, abusing pesticides [57]. BBC News [58] reported suspected accidental herbicide poisoning which resulted to mass deaths. The vulnerable groups, especially children, were at most receiving end of accidental poising. Many cases of pesticide child poisoning were reported in Nigeria [59-62]. Malathion was reported to be preferred preservative agent for stored grains in Nigeria, which might not be allowed to expire before the sale to consumers. Also exposure to gamalin-20 and malathion in poisoned consumables had led to death of many in Nigeria [28]. The effects of PPCPs on living ecosystem in Nigeria are still under investigation. It is also important to note that widely reported paraquat, for its unfriendly impacts on health and environment, is still common place in chemical shops in Ibadan, Oyo State capital.

One of the factors accounted for the outbreak of diseases is resistance of disease-causing pathogens, like bacteria, to drugs. It has been pointed out that persistent of diarrhea among patients in Nigeria was due to resistance of *Escherichia coli* to tetracyclines, penicillins, cotrimoxazole, aminoglycosides, chloramphenicol, ampicillin, gentamicin, penicillins, cephalosporins, streptomycin, and nalixidic acid. Studies conducted in South-West, South-South and South-East Nigeria, revealed that non-typhoidal Salmonella has resisted antimicrobial activities of ofloxacin, nalixidic acid, ampicillin, amoxicillin, cotrimoxazole, tetracycline, gentamicin, ciprofloxacin, and chloramphenicol. Also, resistance to quinolones, ampicillin, penicillins, gentamicin, tetracyclines, streptomycin, chloramphenicol and cotrimoxazole has been observed in *Shigella* species in Nigeria. In the same vein, resistance to chloramphenicol, ampicillin, streptomycin, nalidixic acid, spectinomycin, cloxacillin, penicillin G, trimethoprim, sulphamethoxazole, and sulfonamide by Vibrio *cholerae* in Nigeria [22]. The study further stated that drug resistant bacteria were introduced into the environment through industrial, domestic, solid waste dumpsites, and veterinary wastewaters.

Exposure to Bonny light crude oil has been reported to cause endocrine disruption in Wistar albino rats by influencing levels of testosterone and estrogen in male and female populations [63]. This would point to level of hazards that might have been impacted on aquatic animals in oil spillage regions of Nigerian Niger-Delta. Oil spillage in Nigeria has led to loss of faunal, floral and other living components of ecosystem in the coastal areas. This invariably led to loss of means of livelihood of residents of the oil spillage area, famine as the farmers are no longer have access to the farms, militancy, loss of species, environmental degradation, and monumental economic loss to the nation [64].

In a study conducted to determine the determinants by Nigerian women to choose skincare products, it was reported that skincare products were chosen with beauty and health consciousness but without environmental consciousness [65]. This attitude, if environment is neglected in using the products, will indirectly and eventually impact the general ecosystem including human health.

Abuse of psychoactive drugs left in its trail unholy episodes of health complications. The common place sexually enhanced drug abuse has led to immoral sexual behaviour like raping and promiscuity. These acts invariably predispose to increase sexually transmitted diseases (STDs) including HIV/AIDS. Abuse of psychoactive substances has led to dependence. Dependence on the psychoactive substances' usage by the users led to chronic pain, high blood pressure, heart diseases, diabetes and mentally-derailed population [26].

Industries have been cited as the sources of hazards like fire outbreak, water and air pollution, smoke, and dusts which predisposed to varieties of health complications in Rivers State environment [66].

Chronic exposure to phthalate esters in sachet water can

predispose to hormonal imbalance and eventually birth defects in new born [48]. Plasticizers, being solid organic in environment, provided adsorptive surfaces for diverse organic pollutants and contaminants which eventually entered food chain and ecosystem and wrecked health and environmental havocs [24]. Imo and Akwa Ibom states are among the top 20 ocean pollution points in the world, while it was predicted that in the very near future Lagos beaches may lose their aesthetic, leisure and commercial values to micro-plastic wastes dumped or stormed in [25].

4. Recommendations

The Nigerian government should promote indigenous pharmaceutical companies to produce larger percentage of pharmaceutical needs of the country as against 30% currently being produced. Nigerian pharmaceutical firms need to seek size expansion (in terms of R&D and revenue) as a prerequisite for capacity enhancement by collaborative arrangement [19]. This, if achieved, will boost national gross domestic product (GDP). Also, Nigeria should focus on drug development rather than importation of active ingredients to gain capability for cradle to grave management of drugs and pharmaceutical waste/wastewater. That is Nigeria should evolve green chemistry policy for pharmaceutical administration. Other methods of pharmaceutical management stewardships include introduction of personalized drugs (pharmacogenetics), reverse distribution and standardization of natural medicine.

The adoption of indigenous methods of pest and weed control should be encouraged to drastically reduce propensity of emerging contaminants into the environment. Certain pests can be effectively controlled by using mixture of urine and cow dung; mixture of cow urine, ginger and garlic; traps; wood ash spreading; artificial crows and fermented extract of locust bean seeds [67]. These practices are cheap, environmental benign and human health friendly. The current indiscriminate usage of herbicides for weed control in residential areas should be urgently checked by the government with appropriate policy due to proximity of the applications to public water. Extensive tests should be conducted on the neighbourhood well water for the presence of herbicides.

Global best practices on plastic management should be adopted which include replacement of plastic packaging with compostable materials, ban of single-use plastics, convertible plastics for multipurpose usage, economic incentives on zero plastic waste generation, and aggressive plastic waste recycling [25]. Another method is conversion of plastic wastes into fuel through pyrolysis [68-89].

Nigerian government should also embark on sustainable poverty alleviation programmes and policies and public education on environmental health as related to the human wellbeing.

5. Conclusion

This review has revealed presence of candidates of some of the classes of ECCs in the Ngerian environment. Easy access, economy, rural-urban drift and lack of effective regulatory framework are factors responsible for increase in usage and abuse of ECCs, especially agrochemicals and PPCPs, in Nigeria. Some of the pesticides contained active ingredients, e.g., glyphosate, that had been banned in developed economies. Discriminate usage of agrochemicals and PPCPs had led to presence of these compounds in the environmental media. There is need for government to strengthen the frameworks and institutions that regulate the usage of chemicals. The recommendations mentioned above should be looked into for necessary actions with a view to safeguard the environment, ecosystem and human health.

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