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Effects of Chemicals and Plastics on the Environment: A Review

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ABSTRACT

The United Nations' Sustainable Development Goals (SDGs) of the human population states that good health and well-being as well as building sustainable cities and communities are essential aspects of man's survival here on earth. This paper attempts to review the effects of chemicals, and plastics in our contemporary environment and the innovative solutions for their safe disposal. Indiscriminate use of chemicals, dumping of untreated domestic and industrial wastes in landfills and water bodies, burning of refuse all contribute to the problem. It brings to focus the various means by which these pollutants get into our environment, even unknowingly and ways by which this environmental menace can be minimized. Their presence in our environment, particularly in the developing and under developed world has over the years become a ticking time bomb with recourse to human health. Many debilitating human conditions such as cancers and neurological disorders have been traced to the effects of these pollutants. Public enlightenment on the dangers of these pollutants amongst others is advocated in this work.

1.0 INTRODUCTION

Environment is the aggregate of conditions or surroundings which living beings such as humans, animals and plants live or survive and non-living things exist [1]. All living beings are mutually reactive and affecting one another in different ways. It is generally equated with nature wherein physical component of the planet earth affects life in the biosphere.

Biodiversity is a paramount factor for the survival of the living world in general and mankind in particular [2]. Today, major loss to biodiversity in the world has been due to human overuse or misuse of the natural ecosystem. Due to mindless and unsustainable resource use, once productive forest and grassland have been turned into desert and wastelands. Rapid industrialization, urbanization and growth in population have resulted in massive deforestation and consequential habitat loss around the world [3]. Although natural environment has an in-built capacity to replenish the losses or reduction in its constituents to restore it as sustainable and healthy as required [4].

Human endeavors have perpetuated loss of habitat for flora and fauna, depletion of natural resources at a large scale as well as deforestation. As a result, natural environment continues to be undesirably polluted, leading to debilitating human conditions and well-being. Apart from the natural causes of pollution, human activities and resource utilization are perhaps the crucial sources of pollution. There is no gainsaying that improper disposal and management of waste cause all manner of pollution (air, water and soil) as well as health effects such as dysentery, cholera and typhoid [5]. The indiscriminate dumping of wastes contaminates surface and ground water supplies.Research studies also suggest these contaminations are caused by disease causing organisms, as water seeping through dumps is likely to include viruses of poliomyelitis, hepatitis and gastroenteritis [5]. In urban areas, municipal solid waste block drains, creating stagnant water for insect breeding and floods during raining seasons. Uncontrolled burning of waste and improper incineration contribute significantly to air pollution [6]. Greenhouse gases are generated from the decomposition of organic waste in landfills and untreated leachate pollutes surrounding soil and water bodies.

Health and safety issues also arise from improper disposal of waste. Insects and rodent vectors are attracted to the waste and can spread diseases like cholera [5]. The aesthetic nature of our environment is not spared as heaps of garbage and refuse, scrap metals as well as debris can be unsightly. They litter streets, roadsides verges, beaches and leisure areas, destroying the natural beauty of the environment.

The effects of human activities related to the use of resources on natural environment is referred to as environmental impact while the evaluation of the environmental effect of human activities collectively is referred as environmental impact assessment. Assessing the extent of this impact on our environment viza vis efforts to recover lost grounds is the major thrust of this review.

2.0 EFFECTS OF CHEMICALS ON THE ENVIRONMENT

The effects of chemicals on the environment cannot be overemphasized. While chemicals are vital for human advancement, however responsible management of chemicals is crucial to safeguard health and the environment. Some chemicals can affect human and ecological health when released into the environment. Pesticides and herbicides are chemicals which are adopted in an attempt to have better agricultural yield but results in pollution of the environment [7]. Alarmingly, even trace amounts of specific chemicals such as heavy metals, polychlorinated biphenyls, cyanides, organophosphates, trichloroethylene can disrupt the delicate balance of our nervous system, leading to various disorders [8]. Moreover, they can weaken our immune system's defenses, leaving us vulnerable to infections. Additionally, these chemicals can interfere with hormonal functions, impacting reproductive health and fetal development. Furthermore, they can increase the risk of cancer development [6, 9].

Hazardous chemical is any chemical which can cause a physical or a health problem or hazard [10]. It can exist as solid, liquid or gaseous substances consisting of a single ingredient or mixture of substances. The following are some examples of hazardous chemicals:

(i) Asphyxiants: These chemicals can interrupt the use and transfer of oxygen by the bloodstream, thereby depriving the body of oxygen. Examples are carbon monoxide (CO), carbon dioxide (CO_2), liquefied petroleum gas (LPG) and cyanide.

(ii) Corrosives: Chemical corrosives can cause severe damage to people, property and the environment. They exhibit extremes of acidity or basicity, with pH level of ≤ 2 or ≥ 12.5. They have a tendency to corrode steel or metal. Examples are nitric acid and sulfuric acid.

(iii) Irritants: These chemicals can damage the skin, eyes and respiratory tract of a person, which manifests as redness, rashes, inflammation, coughing and haemorrhaging. Examples are Nickel, nitrogen dioxide, ozone and chromic acid.

(iv)Sensitizers (Allergens): Repeated exposure to sensitizers over time leads to allergic reactions, such as contact dermatitis, swollen airway, asthma and lung disease. Examples are chlorine, nickel, isocyanides, and formaldehyde.

(v) Carcinogens: They are cancer-causing chemicals, whose effects are evident after several years of exposure. Examples are benzene, formaldehyde and radon.

(vi) Mutagens: These chemicals cause genetic changes to a cell's deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). Such genetic changes can result in cancer, disruption of biological functions, and malfunctioning of organs in the body. Examples are benzene and hydrogen peroxide.

(vii) Teratogens: They disrupt normal development of a foetus, causing birth defects. Examples are mercury and ionizing radiations.

(viii) Reactives: These chemicals cause hazards such as explosion when combined with other chemicals or with water or air. Examples are nitric acid, benzoyl peroxide and cyanide.

(ix) Flammables: They ignite on exposure to oxygen. Examples are methanol and acetone.

Sources and Effects of Hazardous Chemicals

(a) Burning of Fossil Fuels: Combustion of petroleum products (diesel, gasoline and liquefied petroleum gas) leads to the production of greenhouse gases (GHGs) such as carbon dioxide (CO_2), methane (CH_4) and chlorofluorocarbons (CFCs) [11]. Increase in the level of GHGs beyond background levels, leads to retention of excess heat by the earth which results in global warming (increase in the average temperature of the earth) [12]. Such warming of the earth may result in consequences such as the melting of the snow in Arctic and Antarctic regions and rise in sea levels, thereby leading to submerging of coastal cities (flooding) [12].

(b) Ozone Layer Depletion: This is caused by chemicals such as CFCs and halons which are used as refrigerants and foam-blowing agents. The depletion of the ozone layer exposes the earth to harmful ultra-violet (UV) radiation.

(c) Water & Soil Pollution: Agricultural fertilizers are considered the leading cause of eutrophication. Fertilizers that are applied by farmers to soil to enhance plant growth are eroded and carried into water bodies through runoff during rain. This ends up in rivers and lakes, excess phosphorus and nitrogen from the fertilizers results in eutrophication. Eutrophication leads to algae bloom, which covers the surface of the water, and prevents sunlight from reaching the water [13]. Consequently, aquatic plants cannot photosynthesize to produce oxygen that is essential for aquatic organism's survival, leading to death of aquatic organisms, which sinks to the bottom and decomposes further depleting the oxygen in the water body.

(d) Health Effects: Release of hazardous chemicals leads to acute and chronic toxicity. These chemicals may cause eye and skin irritation, difficulty in breathing, headache and nausea. Chronic toxicity leads to severe health effects, including cancer, genetic mutations, behavioural abnormalities, birth defects, physical deformations and physiological malfunctions such as kidney failure and reproductive impairment [9].

3.0 EFFECTS OF PLASTICS ON THE ENVIRONMENT

Plastics are constructed from long, synthetic molecules called polymers, primarily built around carbon chains but often incorporating hydrogen, oxygen, sulfur, and nitrogen. In addition to these core components, plastics typically include various additives like colorants, plasticizers, stabilizers, fillers, and reinforcements, tailoring their characteristics for specific applications. The introduction of additives modifies the chemical makeup of plastics, leading to tailored properties like strength, flexibility, and heat resistance, ultimately affecting the cost-effectiveness of the final material. There are two broad kinds of plastics according to how they behave when they are heated, thermoplastics (which soften when they are heated) and thermosets (which never soften after

they are initially moulded). They are used in a broad range of materials including clothing, transport, medical supplies, water bottles, food packaging, electrical items and construction materials. The ubiquity of plastics in buildings is undeniable, with their presence in secondary glazing systems, roof membranes, thermal insulation materials, soundproofing panels, and even the polymer-based formulations used in paints. Plastics provide crucial electrical insulation and facilitate water management through dedicated piping networks in homes.

On the other hand, human behaviour in this 21st century continues to escalate activities that result in environmental damage. No doubt, the plastic materials manufacturing sector is booming, particularly packaging. Despite a glimmer of recycling, the vast majority of plastic waste chokes our planet, either through incineration or environmental pollution [14]. Plastics are often referred to by the acronyms for their chemical formulas examples are Polyethylene terephthalate-PET, Polyvinyl chloride-PVC. Polypropylene-PP. Polystyrene-PS, Low-density polyethylene-LDPE and High-density polyethylene-HDPE Industrial fabricators of plastic products tend to think of plastics as either commodity resins or specialty resins. Commodity resins are plastics that are produced at high volume and low cost for the most common disposable items and durable goods examples are polyethylene, polypropylene, polyvinyl chloride and polystyrene. Stepping beyond everyday plastics, specialty resins are like tailor-made materials, designed for unique needs. Produced in smaller batches and at a premium, they offer unique properties, like the ability to replace metal in plumbing, hardware, and even car parts.

Plastic pollution represents one of the major perceived threats to biodiversity, regardless of the disposal method; all discarded plastic waste constitutes a risk to the environment and organism including humans [15]. Due to their recalcitrance in the environment, it is a cause of special concern. The interaction of organism with plastic debris results in a wide range of consequences, directly and indirectly including the potential occurrence of sub-lethal effects, which owing to their uncertainty may be of considerable concern [15].

Broadly, the presence of large plastic materials in the ocean may result in entanglement and ingestion, potential creation of new habitats and disposal via rafting, including transport of invasive species [16]. Entanglement and ingestion frequently causes harm or death. Debris from plastic may also constitute new habitat and derelict fishing gear. Another potential effect of plastic materials is in the terrestrial environment where it is conceivable that some animals may ingest and at least practically become entangled in areas where these plastic materials are prevalent [14]. Ruminant animals have also been reported to have plastic debris found in their stomach [17].

Owing to their small size, micro plastics may be ingested by multiple organisms like planktonic and higher organism including birds, fish and mammals, the effect of this which can range from ingestion-induced stress such as physical blockage, energy expenditure for egestion and false satiety, leakage of chemicals like additives from plastics and exposure to contaminants absorbed [16]. It is of growing facts that plastic materials has adverse effect on animal life in area of reduced vigor as well as induced malformation processes and neurotoxicity [14].

Tiny plastic bits called microplastics are showing up everywhere, even in our lungs and guts [18]. Scientists are worried these plastics could harm human health because they might physically damage cells: Imagine tiny needles poking your inside. Similar things might happen with microplastics, leading to inflammation, cell death, and DNA damage. They could also trigger harmful reactions: human bodies might overreact to the plastics, causing inflammation and immune responses. Imagine getting allergies from dust, but inside your body. They can also interfere with human brains and metabolism: Studies suggest microplastics might even affect how the brains and bodies function. Workers exposed to high levels of plastic dust have lung problems. Epidemiological studies have reported lung injuries, including inflammation, fibrosis, and allergy, among workers in the plastic industry who are exposed to high amounts of plastic fibrous dust [18].

4.0 IMPACT ON ECOSYSTEMS AND BIO-DIVERSITY

Plastic pollution causes significant threat to biodiversity as a result of their persistent nature and toxicity. It threatens ecosystems, animal and plant species, impeding their ability to deliver essential services to humanity. While the leakage of plastics into the ocean and the subsequent impacts on marine life has been most studied, plastic pollution also affects wildlife.

4.1 Harm to Wildlife

Millions of animals are killed by plastics every year from birds to fish to other marine organisms [14]. Nearly every species of seabird eats plastics. Most of the deaths of animals are caused by entanglement or starvation [14]. Whales, turtles, seals and other animals are strangled by abandoned fishing gear. Micro-plastics have been found in several aquatic species including fishes and shrimps destined for our dinner plates [19]. Plastics have also been found to have blocked digestive tracts or pierced organs causing deaths. Stomachs so packed with plastics reduce the urge to eat, causing starvation. Plastics have been consumed by land-based animals such as tigers, cattle, elephants and in some cases causing deaths.

4.2 Harm to Agricultural Land

The proliferation of plastic in agriculture poses a grave threat. It contributes to soil degradation, disrupts ecosystems, and jeopardizes crucial resource management, hindering both environmental health and agricultural productivity.

4.3 Impact on Environment

The vast majority of plastics persist in the environment for centuries, leading to a multitude of problems. This

includes pollution of land, water, and air, entanglement and harm to wildlife, and potential human health risks due to microplastics entering the food chain. Additionally, plastic exposed to sunlight can break down, releasing additives and potential toxins into the soil, posing a threat to ecosystems. Lurking beneath the landfills, buried plastics threaten to poison groundwater with harmful chemicals. Incineration or open burning of plastics releases a range of pollutants, including dioxins, furans, and volatile organic compounds, known to be harmful to human health and the environment. Furthermore, they cause landscape disfigurement, blockage of channels, rivers and streams [5].

4.4 Impact on Humans

Despite a common perception of being harmless, plastic polymers do pose various risks to society, including environmental pollution, human health concerns, and potential economic repercussions. Chemicals such as phthalates, bisphenol A (BPA) and polybrominated diphenyl ether (PBDE) leached from plastics into air and water have become an emerging area of concern. . The presence of these endocrine-disrupting chemicals (EDCs) – phthalates, BPA, and PBDE – in humans actually became a cause for concern because, for example, Phthalates exhibit anti-androgenic activity, interfering with male hormone signalling. BPA acts as an estrogen agonist, potentially disrupting numerous hormonal pathways. Furthermore, PBDE disrupts thyroid function and possesses anti-androgenic properties. The delicate hormonal balance during critical development phases makes children and women of reproductive age especially vulnerable to disruption by these chemicals. Beyond skin irritation (dermatitis), plastic additives, known endocrine disruptors and carcinogens, can wreak havoc on our internal systems, impacting hormones and potentially leading to cancer, when absorbed through skin contact, ingestion, or inhalation. Microplastics are an ever-growing threat to the health of our planet and its inhabitants. When and if consumed, animals exposed to plastic additives and micro-plastics can be harmful to humans and through the detection of environmental contaminants, bio-monitoring investigations on human tissues have indicated that plastic elements are found in the human species. Reducing plastic pollution and understanding the complexities of microplastics are crucial steps toward a healthier future.

5.0 INNOVATIVE SOLUTION FOR SAFE DISPOSAL OF CHEMICALS AND PLASTICS

The safe disposal of chemicals and plastics is a major global challenge. Traditional methods like landfills and incineration often raise environmental and health concerns. Thankfully, innovative solutions are emerging to address this issue more effectively and sustainably. Here are some promising approaches:

1. Chemical Recycling:
   - Description: This process breaks down plastic waste into its basic building blocks (monomers) through various methods like pyrolysis, solvolysis, and gasification. These monomers can then be used to create new virgin-quality plastics, reducing reliance on fossil fuels and minimizing plastic waste.
   - Benefits: Reduces plastic pollution, conserves resources, and offers a closed-loop solution for plastic waste management.
   - Challenges: Requires significant investment and infrastructure development, and the technology is still under development for some types of plastics.

5.1 Biodegradable Plastics:

- Description: These plastics are made from renewable resources like plant starch or microorganisms and can be broken down by naturally occurring microbes into harmless substances like water and carbon dioxide [20].
- Benefits: Reduces plastic pollution in landfills and oceans, and offers a more sustainable alternative to traditional plastics.
- Challenges: Can be more expensive than traditional plastics, and their biodegradation rate can vary depending on the environment.

5.2 Enzymatic Degradation:

- Description: This approach uses enzymes specifically designed to break down plastic polymers into smaller, reusable molecules. This is a targeted approach that can break down specific types of plastics more efficiently than traditional methods.
- Benefits: Highly efficient and targeted, with the potential to break down even complex plastics.
- Challenges: Still in its early stages of development, and the cost-effectiveness needs further improvement.

5.3 Plasma Gasification:

- Description: This technology uses high-temperature plasma to convert waste, including plastics and chemicals, into a clean syngas (mixture of hydrogen and carbon monoxide) that can be used as a fuel or to produce new chemicals.
- Benefits: Versatile technology that can handle various waste types, and produces valuable resources from waste.
- Challenges: High energy consumption and requires specialized equipment, making it less accessible in some regions.

5.4 AI-powered Waste Management:

- Description: Artificial intelligence can be used to optimize waste collection routes, identify and sort different waste types more accurately, and predict waste generation patterns. This can improve the efficiency and effectiveness of waste management systems.
- Benefits: Optimizes resource allocation, reduces waste collection costs, and improves overall waste management efficiency.

- Challenges: Requires data infrastructure and expertise to implement effectively, and potential ethical concerns around data privacy need to be addressed.

These are just a few examples of the many innovative solutions being developed to address the challenge of safe chemical and plastic disposal. By continuing to invest in research and development, a more sustainable future can be created, where waste is seen as a resource rather than a burden.

It's important to remember that no single solution is a silver bullet, and the most effective approach will likely involve a combination of these and other technologies. By working together, we can find innovative solutions to ensure the safe and sustainable disposal of chemicals and plastics for generations to come.

6.0 CONCLUSION

The use of chemicals, plastics and the indiscriminate disposal of these waste have negatively impacted our environment. Many debilitating human conditions experienced today can be linked to the effect of these pollutants. In our clime, particularly amongst the illiterate class, much attention is not paid to the harmful effects of these chemicals, and as such, acts inimical to man's survival on earth are constantly carried out and thus, the cycle of pollution is entrenched. The way forward for man rests in his ability to identify these pollutants, employ innovative solutions for safe disposal of chemicals and plastics and apply them safely or else search for alternatives that are less detrimental to man and all other living organisms around him.

REFERENCES

[1] Narayan, K.G., D.K. Sinha, and D.K. Singh, *Ecological Concept* Veterinary Public Health and Epidemiology. , 2023. **5**.

[2] Glaubrecht, M., *On the end of evolution – Humankind and the annihilation of species.* Zoologica Scripta, 2023. **52**(3): p. 215-225.

[3] Chakraborty, S.K., P. Sanyal, and R. Ray, *Pollution, Environmental Perturbation and Consequent Loss of Wetlands.* Wetlands Ecology, 2023: p. 521-581.

[4] Agboola, O.P., *et al*., *Built environment transformation in Nigeria: the effects of a regenerative framework.* Journal of Asian Architecture and Building Engineering, 2023.

[5] Oyem, I.M., *Refuse Disposal and its attendant health hazards: A case study of Agbor, Delta State of Nigerias.* Global Journal of Environmental Sciences, 2011. **10**(1 & 2): p. 29-34.

[6] Omoruyi, C.I., J.E. Ukpebor, and E.E. Ukpebor, *Baseline Airborne Polychlorinated Biphenyls (PCBs) Levels Captured By Passive Sampling in Ikhueniro Dumpsite, Edo State, Nigeria.* Journal of Chemical Society of Nigeria, 2019. **44**(7).

[7] Odewale, S.A., E.L. Odekanle, and B.S. Fakinle, *Global Environmental Sustainability and Agrochemical Use. In: Ogwu, M.C., Chibueze Izah, S. (eds) One Health Implications of Agrochemicals and their Sustainable Alternatives*. Sustainable Development and Biodiversity. 2023, Singapore: Springer.

[8] Oyem, H.H., I.M. Oyem, and E.N. Obiwulu, *Barium, Calcium and Sodium, Cyanide, Phosphate and Sulphate contents of groundwater in some Ika communities of Delta State, Nigeria.* Journal of Geoscience and Environmental Protection 2017. **5**(8): p. 89-98.

[9] Fazzo, L., et al., *Hazardous waste and health impact: a systematic review of the scientific literature.* Environmental Health Perspectives, 2017. **16**(107).

[10] Manahan, S.E., *Environmental Chemistry*. 9th ed, ed. T.a.F. Group. 2010, New York: CRC Press.

[11] Ravanchi, M.T. and M. Soleimani, *Global warming and greenhouse effect resulted from oil, gas, and petrochemical units,*
Editor(s): Mohammad Reza Rahimpour, Babak Omidvar, Nazanin Abrishami Shirazi, Mohammad Amin Makarem,
Crises in Oil, Gas and Petrochemical Industries,. Disasters and Environmental Challenges, 2023. **1**: p. 257-282.

[12] Feinberg, A., *Urbanization Heat Flux Modeling Confirms It Is a Likely Cause of Significant Global Warming: Urbanization Mitigation Requirements.* . Land, 2023. **12**(6): p. 1222.

[13] Zhang, J., *et al.*, *Unravelling Nutrients and Carbon Interactions in an Urban Coastal Water during Algal Bloom Period in Zhanjiang Bay, China.* Water, 2023. **15**(5): p. 900-912.

[14] Jangra, R., *Plastic pollution and its adverse effect on ecosystem.* International Journal of Multidisciplinary Research and Growth Evaluation, 2022. **3**(4): p. 441-445.

[15] Narayanan, M., *Origination, fate, accumulation, and impact, of microplastics in a marine ecosystem and bio/technological approach for remediation: A review.* Process Safety and Environmental Protection, 2023. **177**: p. 472-485.

[16] Kannan, G., et al., *Increasing risk of invasions by organisms on marine debris in the Southeast coast of India.* Marine Pollution Bulletin, 2023. **195**(115469).

[17] Priyanka, M. and S. Dey, *Ruminal impaction due to plastic materials-An increasing threat to ruminants and its impact on human health in developing countries.* Veterinary world, 2018. **11**(9): p. 1307.

[18] Vethaak, A.D. and L. Juliette, *Microplastics and human health.* Science, 2021. **371**(6530): p. 672-674.

[19] Lusher, A.L. and G.A. Covernton, *Microplastics in fish and seafood species.* Plastics and the Ocean: Origin, Characterization, Fate, and Impacts, 2022: p. 367-388.

[20] Fahmideh, L., E. Khodadadi, and E. Khodadadi, *A review of applications of biotechnology in the environment.* International Journal of Farming and Allied Sciences, 2014. **3**(12): p. 1319-1325.