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Plastics and Heavy Metals: Implications for Humans

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Article Info

Abstract

This paper performs a literature review regarding the plastics and heavy metals, and effects on humans. Nowadays, industrialization is the champion of world spin. One of the famous manufacturing accomplishment made by industrialization is the plastic. Plastics are polymers made by adding or joining tiny units. Polymers contain other entities beside monomers, thereof, metals (such as heavy metals or the likes), are readily available in plastic chains for various reasons. When plastics are in contact with the soil or water or food, the metals may leach due to pressures. Leaching of metals induce contamination which in turn could affect the biological systems of humans or the likes with effects such as cancers, oxidative stress, hormones destruction, etc. It is therefore, pertinent to inform the public, so that significant measures could be taken to minimize usage and effects of plastics or their co-travelers (additives). Individuals should avoid plastics as ably as possible or reduce plastic use.

Keywords:

Heavy metals, plastics, additives, leaching, human's biological system.

1. Introduction

This paper performs a literature review regarding the plastics and heavy metals, and effects on humans. The areas discussed includes: conceptual review, empirical review, and models related to this work. Polymers are synthetic forms made by linking monomers and additives by industries. Plastics have made ubiquitous applications in almost all human fields. However, due to loopholes in chemistry plastics are potent pollutants for their potential to divulge their metals from their fold to the environment, while contaminating foods, water, soil, and plants. The contamination due to (heavy) metals is able to induce health effects such as diabetes, hypertension, cancers, hormones damage, and many more. By informing the public on these consequences of plastics and heavy metal components, the public and the stakeholders are possibly empowered with knowledge that induce healthy behaviors. Healthy behaviors include refusing, avoiding, recycling, and removing plastics in our midst. This paper forms a review regarding plastics and metals in the fold therewith.

2.1.1 Plastics as Polymers

There are numerous organic materials (compounds) containing thousands of atoms in every molecule in a formation called macromolecule. Some macromolecules are made through joining a huge number of smaller units of molecules called monomers. Monomers are from mono, meaning one; but, the final end product of polymerization (joining of many monomers) is definitely called as polymer (Umar *et al*., 2022). A polymer envisages a repeating units of monomer. There are mostly natural polymers and synthetic polymers among the chemical compounds. Natural polymers are present in living organisms or associated with living matters. Natural polymers could be proteins, fats, carbohydrates etc. Synthetic polymers are made through man instructions and processes. Mostly, plastics are typically best examples of synthetic polymers around us. Plastics are referring to polymers that derived name from Greek " Plastikos" word, which means " to mould". Nowadays, compounds that can be softened by heating or other means and are molded are called as plastics (EPA, 2007; EPA, 2021).

Plastics are divided as thermosets, rubber, and thermoplastics and the possessed differences in structures as shown in Figure 1. Thermoplastics are kind of plastics that can be softened on several occasions through heating and remolding, for example, polyethylene, polystyrene, nylon, polypropene, etc. Thermosets are kind of plastics that once are made are no longer amenable to further molding using heat, for example, Bakelite, urea-methanal etc. Rubber plastics are either natural or synthetic, but they are famous for being elastic in nature, for example, neoprene, *Hevea brasiliansis*. A polymer is describing something by linking many units altogether; the units, that are the "Mers" constitutes the units joined in polymers, and the basic components. Natural polymers can be sourced from natural sources such as lignin's, vegetables, saps, animals (eg turtles, shells, shellack etc.). Widely, hydrocarbons are common examples of polymers of our time consisting of carbon as the backbone, to which hydrogens are bonded. In polypropylene, polyethylene etc. there exists mostly only carbon and hydrogen atoms. Sometimes, other atoms like, oxygen, chlorine, silicon, fluorine, etc. are added in the polymer make ups in many instances; such as in the case of rubber (that contains sulfur), Teflon containing fluorine, polyesters containing oxygen, polycarbonates containing oxygen (Chen et al., 2001; Lyon, 2004).

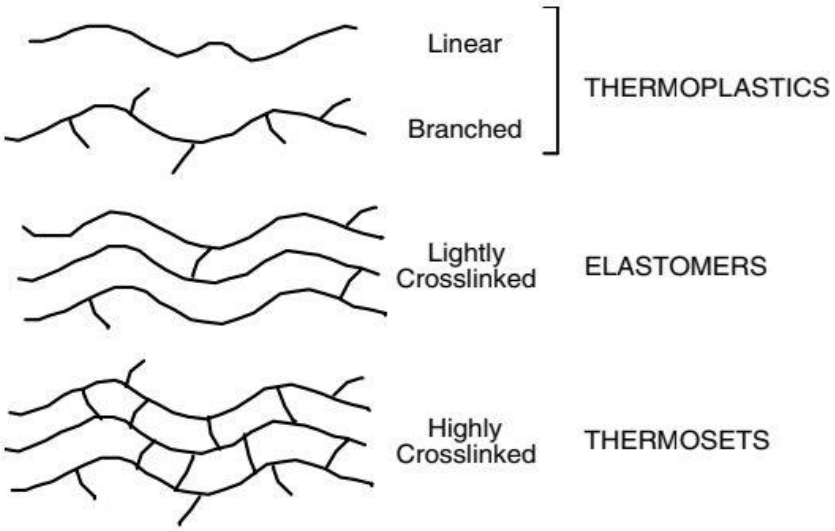

Figure 1: Showing the structure of plastics Source: Lyon, (2004).

2.1.2 Making Plastics

Plastics are made by basic two processes, that is, the condensation, and addition polymerization processes. Addition polymerization is a process envisaging adding monomers to form a polymer that possessed the same empirical formula with the monomer, but different molecular formula (possessing higher molecular mass). Simple, unsaturated molecules are usually added in addition polymerization processes, for example, ethene, propene. In the addition polymerization, no release of smaller molecules is noticed. Some derivatives in addition polymerization are: polyethene, Perspex, polychloroethene etc. (Lyon, 2004; Halden, 201; GESAMP, 2015).

Condensation polymerization is another method of making polymers. It involves a release of a smaller entities such as water. Compounds such as terylene, nylon, are made from condensation methods. Polymerization occurs through steps involving initiation, propagation, and termination. At initiation, the intra-bonds in monomers break (in the case of ethylene) and begin to join to each other. At propagation, continuous addition of monomers to the growing chain is ensured. When the required monomers to make a given polymer are used up, the process halt (Figure 2). Polymers are known with basic characteristics features as follows:

- They are able to act as thermal and electrical insulator materials
- They are light in nature
- They can be made into numerous ways (molds)
- They are regarded as resistant to many chemicals.

In plastics the absent of fillers or things that scatter visible light, the thing is clear. Thermoplastics have linear or linear and branched chains. Are able to flow when heated due to the said nature. Elastomers have lightly crosslinking chains and in turns the ability to be stretched rather than flow. Thermosets have highly crosslinking pattern that is why they are unable to flow when heated Chains that are ordered are crystalline, the contrary chain are amorphous (Lyon, 2004; Plastic Europe, 2016; Pelley, 2018).

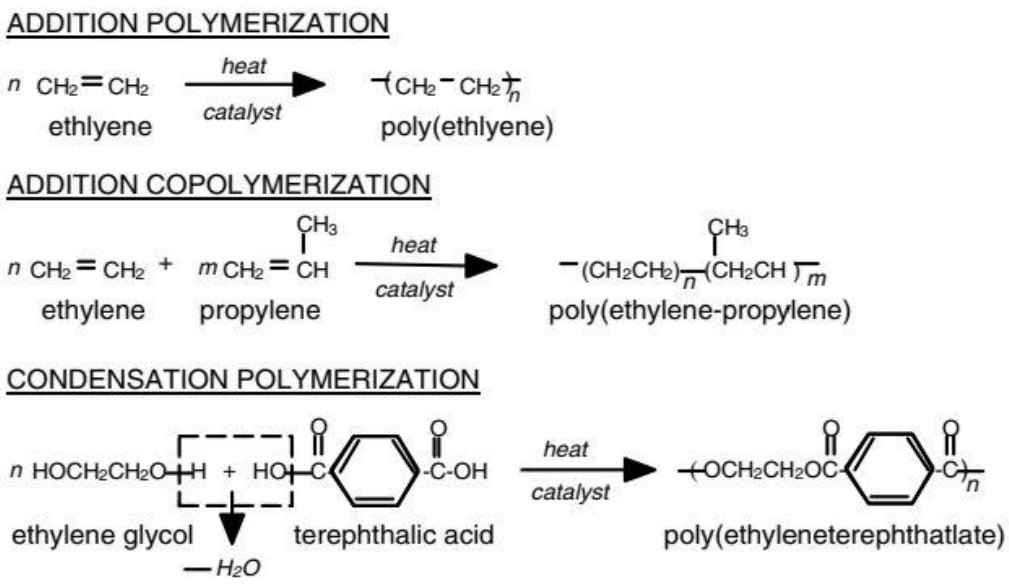

Figure 2:An example of the two types of plastic synthesis processes, Source: Lyon (2004)

2.1.3 Desirable Features of Plastic Materials and Uses of Plastics for Packaging or Wrapping Foods

Plastics are very useful because they possessed many features that are advantageous in nature, as mentioned in the as follows:

- Plastics are strong as well as light, inert to attack by air, water, and other chemicals comparatively
- Plastics are good insulators, they don't conduct electricity and heat (they are poor conductors)
- Plastics can easily be made to meet requirements such as molding as thin, sheets, light, ropes, fabrics, flexible, etc.
- Plastics are cheaper to buy and cheaper to make (Lyon, 2004; Wagner *et al*., 2014; Stenmarck *et al*., 2017).

Plastics have diverse uses in contact with food materials. Like diversity of foods, like diversity of plastic uses in contact with food materials nowadays (Sabilillah *et al.*, 2023). Some of the uses of plastic in food materials storage or handling are as follows:

- As films in cases of bags, pouches, sachets, lids
- As insulators
- As waddings
- As caps
- As bands
- As packs
- As wrappings (in case of biscuits, chocolates, etc.)
- As labels
- As coatings, inks, adhesives (Marin *et al*., 1998; Kirwan *et al*., 2011; Igbo *et al*., 2018; Kour *et al*., 2023).

Other examples of plastic polymers

- Polyvinyl acetate (PA)-Is an amorphous thing with better adhesion strength
- Fluoropolymers-Are made by replacing hydrogens of ethylene with fluorine element
- High nitrile polymers (HNP) -Are made as copolymers to acrylonitrile
- Polymethyl pentene (TPX)-Are kind of methyl pentene co-polymers
- Ethylene vinyl alcohol (EVOH)-Is a copolymer to ethylene and vinyl alcohol
- Ethylene vinyl acetate (EVA)-"Is a copolymer to ethylene with vinyl acetate." (Koushal *et al*., 2014).

2.1.4 Metabolism of Plastics in the Body

Unless, large plastic materials are usually converted to smaller plastics (microplastics and nanoplastics), the intake is difficult. Upon ingestion (through any means) the plastic made its way into the gastrointestinal tract. During translocation, lymphatic system may allow absorption of microplastics; and the intestines carry out absorption of plastics as well. Liver (through the bike), aids in the excretion of some microplastics particles. However, the nanoplastics due to their size enter gut epithelial and are possibly passed on to every organ. Organs such as lung, heart, liver, kidney, spleen, placenta, brain, thymus, reproductive system, receive nanoplastics from the gut. Plastics are able to cause DNA damage, changes in gene and proteins expression, loss of cell viability, tissue inflammation, osteolysis, lesions, oxidative stress, necrosis (Galloway, 2015; Avio et al., 2016; Turner *et al*., 2020).

2.1.5 Classification of Plastics

Plastics are classified based on certain set of yardsticks; sometimes, plastics are classified according to their chemical or physical properties as thermoplastics, Duro plastics, thermosets, and elastomers (Park *et al*., 2013; Verma *et al*., 2016).

- Thermoplastics typically are uncross linked plastic forms up to decomposition temperature. Flow or melting of these plastics take place above the softening point of the " amorphous" type of thermoplastics; and above melting point in a " semicrystalline" thermoplastics (Lyon, 2004).
- Thermoelastomers are plastic types characterized with physically or chemically wide-meshed crosslinks structures that are elastic above the softening (or fusion) temperature, but do not flow viscously up-to the decomposition (or fusing) temperature.
- Elastomers are plastics regarded with chemically wide-meshed and are elastic at lower temperature (below 0 degree Celsius) up-to the decomposition temperature
- Duro plastics are characterized chemically with a close-meshed nature up-to the decomposition temperature, and possessed amorphous nature (Eyerer, 2010; Mikolajewska *et al*., 2015; EPA, 2021; Kour *et al*., 2023).

Types of Plastic Resins

The followings are major plastic polymer resins nowadays:

- Polyethylene terephthalate, abbreviated as PETE is found in water bottles, salad domes, containers, biscuit trays
- High Density Polyethylene, abbreviated as HDPE is found in shopping bags, milk bottles, crates, pipes, detergent bottles
- Polyvinyl chloride, abbreviated as PVC, is found in things like wall cladding, shoe soles, cables, blood bags, tubes, fittings, cosmetics

- Low Density Polyethylene, abbreviated as LDPE, is prevalent in garbage bags, tubing's, plastic mulching, squeeze bottles
- Polystyrene, abbreviated as PS is prevalent in cutlery, brittle toys, building, insulation, cassettes, electronics, automobiles etc. (Halden, 2010; Maret, 2016; Umar *et al*., 2022).

2.1.6 Humans Take in Plastics Through Ingestion, Drinking, and Inhaling

Recent studies have illustrated that food materials being consumed by humans contain plastic particles. For example, wild life (consumed by humans), beer, salt, shell fish, oysters, clams, sugar, etc. taken by humans are reported to contain plastic particles in their folds. Likewise, studies had shown that humans inhale plastic particles that part of it dwell in the lung and ultimately be releasing harmful additives (such as heavy metals) in the body. Nanoplastics can traverse the human body through skin, since they are present in cosmetics and relations (Alabi *et al*., 2019). Plastics used to store food or wrap foods are directly in contact with food materials. Thus, possibly an interaction or reaction occurs especially due to the additives or sorbed chemicals. A famous process of permeation needs to be considered at this juncture. In permeation a solution or chemical is taken by one plastic surface and be release by opposite surface (Kirwan *et al*., 2011; EPA, 2021).

2.2.7 Plastics Affect Animals

Plastics floating or masa flowing from land to water are on many occasions ingested by aquatic or land animals because they mimic food and attractive. Intake of plastic by animals at least cause malnutrition (eg in salmon, sea turtle, fishes) and other adverse effects. Animals affected by plastics are many. Some of them reported include, lugworm, mussel, sea cucumber, shrimp, barnacle, Scenedesmus, sea scallop, etc. (FAO, 2018; Sarkingobir et al., 2021). Some of the reported specific effects observed in animals due to plastic are as follows:

- Blue mussel- aranulocytona formation, internal blockage, injuries, starvation, bioaccumulation
- Carp species- Effects on fat metabolism and behavior
- Fish- Injuries, death
- Rat- Lung inflammation
- Reef- Reproductive effects, growth effects, entanglement
- Turtle- ulceration, internal blockage, deformed organs, entanglement, perforation, death
- Humans-Infertility, heavy metals poisoning, childhood development defects, birth defects, immunity defects, cancers, adult onset diabetes, early puberty, obesity, impaired central nervous system, cellular damage (necrosis, apoptosis) (Lusher *et al*., 2017; Campanale *et al.,* 2020; Umar *et al*., 2022).

2.1.8 Microplastics, A Great Plastic Concern

Microplastics are plastics regarded as small entities when compared to the larger macroplastics. They can be made either as primary or secondary microplastics. Primary microplastics are deliberately made at smaller size; for example, fibers, pellets, abrasive etc. Secondary microplastics are resultantly made from microplastics breaking down or fragmentation (such as in the case of tyres, food packages, ropes, bags, etc.). The minute nature of microplastics allow them to get into any level of the environment, and possibly be ingested by animals and taken along the food chain; and they are capable of being taken up by humans (or other animals) through foods, drinks, and air (van Houtan *et al*., 2016; Alabi *et al*., 2019). Microplastics are dangerous at least in the following domains:

- They are highly reactive to biological materials

- They possessed complex morphological features (such as long tubes, hard edges, mixed composites), they have stability,
- Contain antimicrobials,
- Contain hazardous additives such as heavy metals that are easily divulge (for example, a person taking 3kg of food is probably consuming 250 micro kilogram of plastic materials (Galloway, 2015).
- Usually, plastic come across chemicals before, during, and after it's intended use, and therefore, takes in hydrophobic substances to act as carrier of hazardous chemicals,
- Ability to relate with biomolecules such as DNA, proteins, enzymes, receptors, transduction pathway, etc. (Lindwall, 2020).

3.1.1 Single-Use Plastics

Single use plastic means any kind of disposal plastic material or item that is initially designed to be used once (many of them are displayed in Figure 3). They can be found in packaging, bags, disposal utensils, beverages bottles, water bottles, coffee cups, wipes, straws, packaging etc. However, they are dangerous despite being cheap, ubiquitous, and sometimes irreplaceable. They are dangerous because of their negative effects on health, food consumption, society, environment, and economics (Center for International Environmental Law, 2019).

Figure 3: Examples of some dominantly used single-use plastics, Source: Umar et al., (2022)

3.1.2 Single-use Plastics of More Concern

The followings are some plastics of concern to all (Lusher *et al*., 2017; Umar *et al*., 2022).:

- Plastic bottles- eg water bottle, drink bottle, toiletries, detergent bottle. The concern is, about 150 plastic water bottles are used by an average in UK. Hence, there is need to avoid these plastics, reuse plastic bottles, use tap water, use solid soap
- Food Wrappers such as packets, sweet wrappers, snack wrapping, therewith, about 8.3 billion of them are used annually in UK; 0.3 billion crisp are discarded. Proper methods should be used, recycling should be intensified
- Cigarette butts- 95% of cigarette filters are made from a slow degrading compounds; 79 % cigarette waste is littered in the street. It is good to avoid cigarette

- Food takeaways-About 5.2 billion plastic food containers are utilized annually on the UK; 0.3 billion of which are discarded. It is good to avoid plastic food packaging; reduce using plastics food packaging
- Cotton buds sticks-About 13.2 billion buds containing plastic materials are used in UK yearly; 10 percent are discarded in toilets. This give plastic to soils and waterbodies. Use alternative ways to make cotton buds is better.
- Cups for coffee, smoothies, juice etc. About 4.1 billion drinking cups and covers are used every year in UK, of which 0.5 billion are discarded. Use alternative Cups-Sanitary materials and products such as toilet wipe, face wipe, baby wipe etc. About 3.4 billion plastic wipes are thrown in the toilet in UK every year. Use of water only while cleaning is better, and use of alternative forms of sanitation is paramount.
- Smoking packaging such as cigarette pouches, box lining- No one knows how much cigarette/smoking related plastics are littered. Hence, make every move to avoid smoking, it is dangerous
- Cutlery, straws, stirrers-In UK, every year, 4.7 billion straws, 16.5 billion cutleries, 44.1 billion stirrers are utilized. It is good to reduce the use plastic materials as ably as possible
- Bags such as grocery bags, mail bags, etc.-Bags takes about 25 years before being completely degraded and they are everywhere you go. Hence, avoidance of single use plastic bags is good and reduction of single-use plastic utilization or use alternative of alternatives is better (Earth Watch Institute, 2018).

3.1.3 Single-Use Plastics and Pollution

"Although single-use plastic pollution accumulates most visibly on our streets, in fact our water suffers even more. Litter can be the first stage in a waste stream that enters waterways as plastics tossed on the street are washed away by rain or travel via storm drains into rivers and streams. Our waterway plastic pollution is particularly concentrated: Just ten rivers carry 93 percent of the world's total amount of plastic that enters the oceans via rivers each year. In 2015 researchers from the University of Georgia estimated that between 4.8 million and 12.7 million metric tons of plastic per year make their way into the oceans via people living within 30 miles of a coast. The majority of this pollution—dominated by single-use plastic waste—comes from countries lacking infrastructure to properly manage waste, particularly in Asia. India, for example, generates 25,940 tons of plastic waste every day but collects only 60 percent of it" (Lindwall, 2020).

"Marine animals bear the burden of this influx of garbage into their habitats. Beached whales have been found with stomachs full of plastic trash. And recent studies found plastic in the guts of 90 percent of the seabirds tested and 100 percent of the turtles. Alarmingly, scientists estimate that there will be more plastic than fish in the ocean by weight in 2050. Not only is plastic estimated to kill millions of marine animals and seabirds each year, but it's also contaminating seafood that humans have relied on for millennia, particularly with microplastics in animals' guts" (Lindwall, 2020).

Our addiction to plastic also has negative impacts on the climate. A recent report showed that plastic production contributes to planet-warming greenhouse gas emissions at every point in its life cycle. The process of drilling for plastic's source materials, oil and gas, leads to methane leaking and flaring and is often combined with clearing forests and wetlands that otherwise would have sequestered carbon. Refineries where crude oil is turned into plastic make up one of the most greenhouse gas–intensive industries in the manufacturing sector. And "cracker plants"—which break, or "crack," ethane molecules, a component of natural gas, into the chemical building blocks of plastic products—are energy intensive and highly polluting. In 2015 a mere 24 of these ethane cracker facilities in the United States had the combined carbon output of 3.8 million passenger vehicles. And the recent fracking boom, resulting in a surplus of oil, is fueling a subsequent rise in cracker plants, too. That's bad news for our carbon reduction goals: if plastic production continues unabated, its greenhouse gas emissions could reach 1.34 gigatons

per year by 2030—equal to adding nearly 300 new coal-fired power plants—even as the need to curb global climate change becomes more urgent (Lindwall, 2020).

“Plastic pollution—whether in our oceans, piling up on our coastlines, or contributing to our climate crisis—impacts vulnerable communities first. Even if plastic doesn’t end up in the ocean, recycled plastic is often exported from high-income countries to developing countries to process. But the sheer amount of plastic waste inundates communities until they are drowning under thousands of tons of plastic trash. This is the case particularly in Southeast Asia, which has begun to import much of the plastic that used to go to China for recycling. Not only does the waste destroy the land itself, but when plastic is incinerated (as is the case for unrecyclable plastic at some illegal facilities) its toxic fumes quickly become a health hazard for residents, leading to everything from skin rashes to cancer. Such is the case with many environmental crises: the worst effects are pushed onto overburdened communities with the fewest resources to fight back” (Lindwall, 2020; Al-Thani *et al*., 2023).

3.1.4 How to Reduce the Possible Impacts of Single-Use Plastic Products as Source of Heavy Metals

Recycling Types

Recycling can be in forms such as mechanical, and chemical recycling.

Chemical recycling is the employment of processes that chemically degrade the monomers or relations that basic of the polymer. In turn the end products could be utilized in another polymerization to make new things or fuels. This method is costly, and therefore utilized limitedly. Parable, pyrolysis (cracking) is a depolymerization of polymer to make fuels or raw materials. Pyrolysis decompose a polymer without the presence of oxygen into liquid or gas compound. Other examples are as follows: Econyl process to depolymerize nylon chemically, Vinyl loop-process used in PVC, Crea Solve $^{(R)}$ process of using solvent to depolymerize or dissolve polymers (Stenmack *et al*., 2017; New Jersey Department of Health, 2016; UN Environment Programme, 2021).

In mechanical recycling, mechanical energy is applied to melt plastic, that is the thermoplastics to make new ones. In this process, shredding, drying, sorting, granulating, as well as compounding are employed in making new plastic items from the old ones. Mechanical recycling with "close-loop" make new plastics (from old ones) and still maintain quality and nature (ensures it is intach); while "open-loop" make new products that are of low value compared to the old ones (Edjero *et al*., 2016; WWF-Australia, 2018).

Legislation and policies

Legislation and policies are key to solving many plastics problems (Khan *et al*., 2008; Tschinkel *et al.*, 2020). Parable, Denmark in their law restated that" Consumers are allowed to buy products that can be recycled, and are less problematic." Norway has a policy that says " Pollution shall not harm health or environment." Additionally, countries under EU are to abide that, use of substances like Pb, Cd, Hexavalent chromium, and relations is restricted; concentration of persistent organic pollutants (POPs) shall be limited. Thus, many policies are needed and laws shall be made to alleviate pollution effects. Bangladesh in its own wisdom put a ban on plastic bags entirely; China has put a ban on free plastic bags; Ireland has reduced plastic bag use by 90 percentages; in 2005 were banned in Ruwanda (EPA, 2021).

Energy Recovery Processing

Plastics contain vast energy that can be utilized in buildings for provision of electricity (EPA, 2021).

Manual picking of plastics

This is a method used in picking plastic before processing. Typically, plastics are laid on a space for workers to pick different types, and it can be done by machines or engines such as wind sifters, star screens, trommel screens etc. (EPA, 2021).

Educational Approach

Involves providing suitable messages, materials, tools to help the public communities know many things about plastics and their harms. Education can also be obtained from schools though organized curriculums, courses, seminars, etc.

Composting of Compostable Plastics

It is believed that some plastics can be made as compostables. However, the concern is it might be difficult for laymen to separate plastics and suitable environment for composting is needed (EPA, 2021).

4.1.1 Metals in The Environment Affecting Man and Other Biological Systems

There are different types of metals in the environment (as shown in figure 4). Albeit, metals are naturally in rocks, soils, volcanoes, etc., metals are introduced into environmental spaces that interact the man directly or at proxy as a result of anthropogenic activities (Good Laxson, 2017; Olagunju *et al*., 2020). Extensively, on many occasions, the term heavy metals have been used to refer to metals that are pollutants in nature. A heavy metal has to have a density of more than 5. Metals are not degraded by biological actions in most of the occasions, therefore ingestion or intake of metals might be dangerous to human health (Jaishankar *et al*., 2014; Valentine, 2018; Muhammad *et al*., 2023).

N	Classification A	Classification B	Category examples
1	Non-essential metals	Extremely toxic heavy metals	As, Cd, Hg, Pb, Se, Sn, Tl
2		Precious heavy metals	Au, Ag, Pd, Pt, Ru
3		Radionuclides metals	Am, Pr, Ra, Th, U
4	Essential metals	Micronutrient metals	Co, Cr, Cu, Fe, Mn, Mo, Ni, Zn
5		Macronutrient metals	Ca, K, Mg

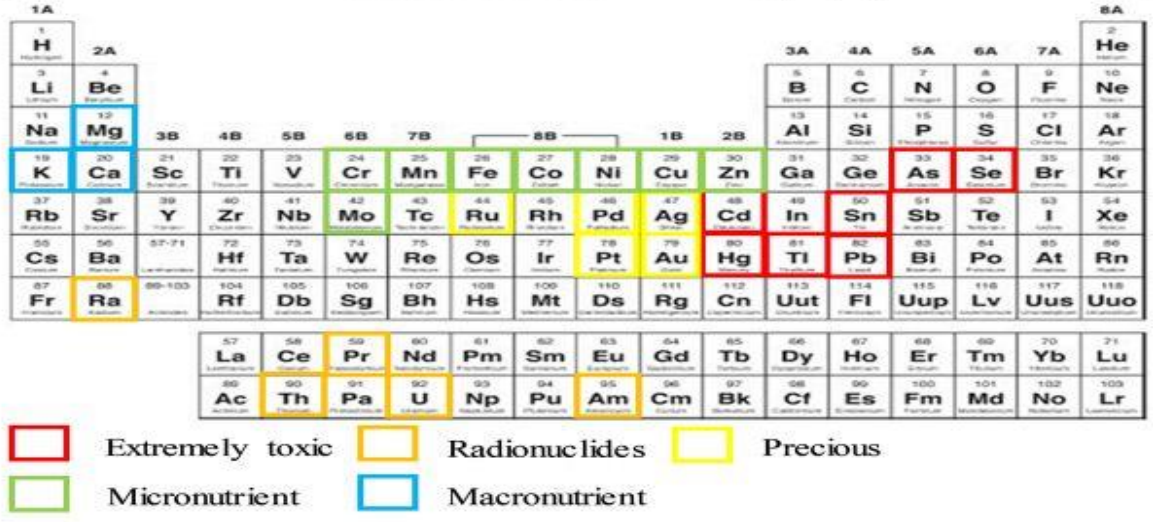

Figure 4: Showing metals (including the heavy ones) classified based certain criteria, Source: Muhammad et al., (2023)

Cadmium Heavy Metal

Cadmium is divalent, and exert similar chemical properties like zinc, or mercury. It is widely found in the lithosphere, low in rocks with a mean of about 200-300ppb. Global production of cadmium is around 20000 metric tons every year mostly from Canada, Belgium, France, Russia, USA, and Japan. Uses of cadmium include:

- Electroplating of iron, copper, steel, brass, and rests of alloys for corrosion abatement
- Act as coloring agent in paints, textiles, fabrics,
- Act as plastics stabilizing agent
- Manufacturing of batteries
- Manufacturing of screens, batteries, and pesticides

Cadmium ion is absorbed in humans and widely distributed to all parts of the body through bloodstream, but the most affected are liver and the kidney. It has the ability to make ligands (a coordination with compounds containing sulfur, zinc, nitrogen, etc.). It replaces zinc in its various enzymes, and seriously the elements damage tubules of the kidney. It is associated with fatal lung, high blood pressure, heart disease etc. Cadmium causes itai-itai disease, anemia, bone disorders (Witkowska *et al.*, 2021; Batool *et al*., 2023; Charkiewicz *et al*., 2023).

Lead Heavy Metal

Lead is a metal predominantly found in rocks, and soils in the earth with about 16ppm mean concentration. In industrial applications lead is used in ammunition, brass, bronze, cables, bearings, casting of metals, solder, foil, tubes, pigments, chemicals, annealing, plating, galvanizing etc.

Lead is made from ores such as galena (PbS), cerrusite ($PbCO_3$), and anglesite ($PbSO_4$). Extraction of lead is mostly through galena by roasting of ore initially, and reducing the lead oxide by carbon.

$$2PbS\ (s) + 3O_3(g) \longrightarrow 2PbO(s) + 2SO_2(g)$$

$$2PbO(s) + C(s) \longrightarrow 2Pb(s) + CO_2(g)$$

Physical Properties in lead

Appearance is usually greyish-white solid and have luster; relative density is 11.3; ductility is naught, fairly strong tensile strength, 327 degree Celsius as melting point, malleable, and conducts good heat and electricity

Chemical Properties includes:

- Lead reacts in moist air to make lead (II) oxide as a coat, lead (Ii) hydroxide, and lead (Ii) Tri carbonate
- Lead does not reacts with acids because of its outside insoluble layer, but, hot concentrated tetraoxosulphate (VI) acid to give out hydrogen and sulphur (IV) oxide.

- Lead has no recorded activities with alkalis (Witkowska *et al*., 2021).

Lead upon entering the body is poisonous to almost all parts. It affects bones by replacing calcium, and has the ability to affect many enzymes thereby inhibiting them. It damages nervous system, leading to permanent lesions and poor mental development in youngsters. Moreover, the heme system in the body is on many occasions being prevented by lead metal by inhibiting the ALA-dehydrogenase enzyme and in turns preventing the hemoglobin synthesis (Isah *et al*., 2021; Al-Thani *et al*., 2023).

Chromium Heavy Metal

Mostly, the chromium is gotten front its ore called Chromite. Other sources are Ferro-Chromo and chromium metals as well. It is used in tanning, and prevention of corrosion. Chromium exists as ions hexavalent and trivalent forms. Humans come in contact with chromium through water, air, food, smoking, occupations, dirt, dust; and when absorbed hexavalent chromium is toxic to humans. Humans mostly store chromium in skin, muscle, fat tissues as well. Some effects of chromium toxicity include digestive tract cancer, lung cancer, genetic damage, etc. (Khan *et al*., 2008; Umar *et al*., 2022).

Copper

Copper is a low toxicity element and used in electrical transmission and is gotten from copper sulfide mining.

Indeed, copper is essential to plants and animals, it acts to activate many enzymes and act as chelators of organic materials. For, example, cytochrome C-oxidase, superoxide dismutase, tyrosinase, dopamine beta-hydroxylase require copper for their activities(Appen Roth, 2010).

Toxic effects

Excess amount of copper in the body can cause genotoxicity, and it accumulates in the liver and brain to bring about diseases. Copper causes Wilson disease characterized with psychiatric symptoms and requires medication, low copper diet, and sometimes liver transplant (Jadaa and Mohammed, 2023).

Copper is regarded as the peakest electromagnetic element in the first row consisting of transition metals. It possessed a large positive electrode potential and reside low in the activity series, it is also relatively unreactive element. Copper is useful in making electric wires, and in fact it is best for that purpose after silver metal. Copper is widely applicable in metal works, roofing, and in plumbing purposes. Also, important alloys such as bronze, brass, cupronickel are made from copper metal. Some important copper compounds include, copper(II) oxide, copper (I) chloride, copper (II) hydroxide, copper(II) trioxonitrate (V), copper(II) trioxocarbobate, copper (II) tetraoxosulphate (VI), etc. (Apenroth, 2010; Mahur Pawar, 2015; Tschinkel *et al*., 2020). Physical properties of copper are as follows:

- Appearance is soft, solid, red, and lustrous
- It has a relative density of 8.95
- It has a nature of malleability
- It has relatively high tensile strength
- It has a melting point of 1080 degree centigrade

- It has a conductivity that is excellent in relation to heat or electricity

Chemical properties of copper include the followings:

- It reacts with hot concentrated acid, that is sulfuric acid to liberate sulfur dioxide.
- Copper allows itself to be displaced from solutions of its salts by many metal entities (Mahur Pawar, 2015; Aliyu, 2020).

Zinc Heavy Metal

Zinc is a known moderately reactive metal. Zinc is found in its ore known as calamine, and zinc blender mostly. Zinc is regarded as a transition metal, and is having only an oxidation of +2, uncolored ions, as well as not used as catalyst mostly(Adepoju-Bello et al., Jadaa and Mohammed, 2023).

Physical properties of zinc include the following items:

- It has a relative density of 7.1
- It is bluish-white, and solid in nature
- It has a lustrous appearance
- It is malleable as well as ductile
- High tensile strength is also possessed by zinc
- Zinc has a melting point of about 419 degree Celsius
- It is a good conductor of electricity, and heat (Mahur Pawar, 2015; Jadaa and Mohammed, 2023).

Chemical properties of zinc include the following features:

- Under a prolonged air exposure, zinc tarnishes due to oxidation forming zinc oxide and relations
- It reacts with water, that is steam at red heat to divulge oxygen
- When subjected to heating, zinc react with nonmetals (halogens for example) to make specific compounds
- Reaction between zinc and acids that yield displacement of hydrogen is a property of zinc. And also oxidation with strong oxidation agents like concentrated nitric acid given compounds are liberated.
- Zinc is an amphoteric one that rea ct with hot alkalis to make zincate (II), and the hydrogen (Duruibe *et al*., 2007; Adepoju-Bello *et al*., 2012; Mahur Pawar, 2015).

Uses of zinc are many. Some of them are listed below:

- Zinc is used to galvanize iron, and steel in order to halt rusting

- Zinc is used in making alloys such as brass, and coinage bronze
- Zinc is used to make batteries (cells), plates, and act as a reducing agent metal.
- Some examples of important zinc compounds can be zinc oxide, zinc hydroxide, zinc trioxonitrate (V), and zinc tetraoxosulphate (VI) (Dris *et al*., 2018; EPA, 2021; Jadaa and Mohammed, 2023; Sarkingobir *et al.,* 2023).

4.1. 2. Copper and Zinc as Nutritionally Essential Entities

What are Heavy Metals?

Heavy metals are mostly regarded as group consisting of metallic elements that are comparatively denser than others and are supposedly harmful even when the concentration is minute. They are in a group envisaging some elements that are specifically metals, and some that are specifically metalloids. They also have a density that is above 5gcm-3, and an atomic mass ranging from 60-200. Heavy metals are popularly supposed to be comparatively non-biodegradable and are poisonous or toxic such as in the case of lead, cadmium, chromium etc. Others are believed to play some useful roles in the zinc, copper, etc., but even the essential heavy metals behave in a toxic manner when the concentration being taken by a biological system are large (excess). At this juncture, heavy metals could be essential or non-essential based on the aforementioned narrations (EU, 2011; Jadaa and Mohammed, 2023).

Essentiality of Copper to Biological Systems

Copper is third most prevalent metal in the body acting as mineral. It is the most dominantly found in liver and brain among other metals. No reactions or chemicals processes no biological systems, and these reactions are speeded up always by enzymes. In this vein, copper is a useful component of enzymes such as cytochrome c oxidase, ascorbic acid oxidase, peroxidases, lactase, ascorbic acid oxidase, tyrosinase, superoxide dismutase, and many more. Copper is needed for functioning of neurological, and hematological human systems. Growth and development of bone needed, myelination of neurons, hemoglobin incorporation, iron absorption in the GIT, and iron translocation into tissues, are all possible due to copper (Soetan *et al*., 2010).

Human or animal low copper intake (deficiency) could spur effects such as cardiac failure, anemia, abnormal hair, bine abnormalities, poor cognition, GIT problems, etc. In plants copper serve as component of redox enzymes as well as lignin synthesizing enzymes. Thus, deficiency causes chlorosis, growth stunting, necrosis of young leaves, etc. (Soetan *et al*., 2010). Mostly, occurring copper deficiency in infant cause fatigue, anemia, low number of white blood cells of the blood, osteoporosis, weak muscle, confusion (Soetan *et al*., 2010).

Essentiality of Zinc to Biological System

All living cells are composed of zinc, and it is distributed in all tissues of plants and animals because of its role as cofactor of enzymes such as glutamic dehydrogenase, carbonic anhydrase, lactate dehydrogenase, retinene reductase, superoxide dismutase, alkaline phosphatase, etc. Zinc has other diverse roles in the biological system as mentioned below:

- Zinc act in cell replication, gene expression, amino acid metabolism, and nucleic acid metabolism
- Wound healing, fertility (of birds), tissues repair, and insulin integrity, requires zinc

- Birds also need zinc for growth and development of their skeletal system, epithelial tissue system, egg synthesis
- Zinc deficiency could cause effects like depression, parakeratosis, poor growth, poor intelligence, lesions in osteogenic processes, embryonic defects, etc.
- In plants, zinc is actively involved in chlorophyll synthesis, enzymes activities, activation of chloroplast, synthesis of hormone auxin, synthesis of starch; whereas, deficiency due to zinc manifest as chlorosis, poor leaves, and abnormal roots (Goyer and Clarkson, 2001; Witkowska *et al*., 2021).

4.1.3. Lead, Chromium, and Cadmium as Metals with No Known Benefits

Public Health Effects Due to Lead

In humans almost there is no known function of lead and it has the ability to affect every nook and cranny of the body. In fact, no safe level of the element is known. Lead is a popular heavy metal and has ability to affect nearly all parts of the body as indicated below:

- Effects on the nervous system due to lead can be fatigue, motor difficulty, headache, anxiety, low cognition, emotional disturbance, irritability, etc.
- Effects on the hematology can be iron deficiency anemia, and impaired heme synthesis
- Effects on the renal system can be chronic renal failure, tubular dysfunction, nephrotocity, inhibition of uric acid secretion, hyperuricemia etc.
- Effects on the cardiovascular system envisage heart disorders, heart rate variation, heart diseases, stroke (Mohsin, 2022).
- Effects on immune system envisage increased infection, sensitivity, and suppressed system
- Effects on reproductive system envisage poor sperm mobility, miscarriage, low-birth weight, shuttle thorough breast milk
- Effects on the hepatic system include effects on the cholesterol, and xenobiotics metabolism (Mohsin, 2022).
- Noteworthy children and youngsters are more affected with lead toxicity. Children suffer additional effects such as seizure, learning difficulties, lower IQ, behavior problems (Soetan *et al*., 2010).

Public Health Effects Due to Chromium

Upon exposure to immediate dosage of chromium the following harmful observations can be reported: irritation of skin, and eye (damage of the eye can occur), coughing, wheezing can occur due to irritation of nose and throat. Flu-like symptoms can occur, while, upon exposure on chronic basis, chromium effects such as cancer, reproductive effects, hole in bones, skin allergy, asthma-like allergy, skin burning, chest tightness, liver effects, kidney abnormalities (New Jersey Department of Health, 2009; Alam *et al.*, 2019; Witkowska *et al.*, 2021).

Cadmium Public Health Effects

Cadmium have the potential to accumulate in liver, kidney, pancreas, muscle, adipose tissue, testes, skin, and inhibits sulfur- containing enzymes. On most of the body parts the following effects are noticed:

- Respiratory system is affected by disruption of the tract, edema, bronchitis, coughing, dyspnea
- On nephrological part effects such as proteinuria, increased creatinine, increased urination, and nephropathy

- Effects on skeleton system could be demineralization in bones, osteoma Acia, itai-itai disease, osteoporosis, reduced vitamin D metabolism, and reduced calcium effort
- Nervous system toxicity could be neurodegenerative disorders, etiopathogeneses', cognitive deteriorating, poor memory, poor attention, psychomotor abnormalities.
- Hypertension, impaired heart, stroke, atherosclerosis are effects on the circulatory system (Fesseha and Abebe, 2019; Jadaa and Mohammed, 2023).

4.1.4 Public Health Effects of Excess Copper, and Zinc Essential Metals

Public Health Effects Due Excessive Copper Intake

Despite being especially, high copper intake is a condition that lead to toxic effects as well. High copper in the body can manifest as nervous system disturbance, histapenia, increased histamine and ceruloplasmin proteins, inactivation of tyrosinase, inhibition of dopa decarboxylase (a useful enzyme in dopamine making); therefore, a depressed dopamine level is cause by excess copper. Copper excess inhibits basic pathways of metabolism (such as hexokinase, pyruvate kinase, lactate dehydrogenase needed for glycolysis). Schizophrenia is well related to copper excess in the body, as well as Parkinson disease, and adult insomnia. Other effects due to copper intoxication could be loss of hair, tinnitus, abnormal nails, stuttering, hypertension, tremor, and depression (Jadaa and Mohammed, 2023).

Similarly, hypertension is a show of excess copper, renal (necrosis, tubule destruction) and hepatic effects (such as necrosis, lysosomal copper loading, cessation of normal metabolic hubbing). Copper level in excess in the body could be sign of malignancy (cancer); increased estrogens levels, dementia dialytica, and copper intoxication are related effects of excess copper (Pfeiffer and Mailloux. 1987). At a nutshell, short-term effects of excess copper envisage skin and eye irritation, coughing, wheezing, nausea, diarrhea, vomiting, abdominal pain. Longterm exposure could instigate chills, headache, fever, skin allergy, skin rash, kidney damage, liver effects, bleeding, etc. (Beaman *et al*., 2016; New Jersey Department of Health, 2016; Aliyu *et al*., 2017; Witkowska *et al.*, 2021).

Effects of Zinc Excess

Acutely, zinc cause irritation of skin, irritation of eyes, irritation of nose, throat irritation, coughing, wheezing. It also causes aches, chills, fever, chest tightness, and, cough. Chronic effects of zinc in humans include, reproductive hazards, dermatitis, thirst, nervousness, gloominess, fatigue (New Jersey Department of Health, 2021; Jadaa and Mohammed, 20223).

4.2.0 Empirical Review

4.2.1 Identified Heavy Metals (Namely Cadmium, Lead, Zinc, And Copper) In Plastics

Noteworthy, it was reiterated by a study from China, plastics various applications are threatening the environment, in turn humans are most likely of concern among the other biological beings affected by plastic pollution release (Alam *et al.*, 2019). An analysis of typical food containers (single use plastics) made from polyethylene terephthalate and polypropylene obtained from different districts in India revealed that, there was significant migration of heavy metals (namely, lead, copper, zinc, among others0 from the plastic containers according to the extent of added temperature that greatly contribute to the migration of the affected metals (Khan and Khan, 2022). Another investigation of polyethylene, high density polyethylene and polyvinyl chloride single use plastics bags in China revealed a varying levels of lead, cadmium, copper, and zinc heavy metals, so there is a potential of the plastic involved to cause toxicity due to the revealed heavy metals (Alam *et al.*, 2019).

In another work from the one of the fastest rising type of waste, that is waste from computers (E-Waste) conducted in Ibadan, Nigeria, upholds that, the lead and copper varies and are in the levels above the threshold limit concentrations (TLC), indicating the toxicity of the analyzed waste (Olubnajo *et al*., 2019). In this vein, due to the inappropriate methods of disposal of waste of this type, the observed concentrations of copper and lead could threaten man and his environment as well (Olubanjo *et al.,* 2019). In a related development, a Lagos study of soils that contains E-waste (plastics) is managed in a chaotic and inappropriate manner has led to environmental pollution that is of detriment to health. This study unveiled that, copper, zinc, lead, and cadmium metals among others assessed in soil of the waste disposition area were of toxicity concern (at various levels, including the ability to cause concern in case of lead and cadmium). Therefore, more enlightenment was suggested (Adeyi *et al*., 2019). Some different types of television sets collected from Lagos and Enugu for heavy metals analysis in plastic made from 1980-2000 shows that, zinc, copper, were high above threshold limit concentration and suggesting a possible hazard to environment and human (Okenwa-Ani *et al*., 2019).

Jallo *et al*., (2021) studied the waste management practices in a Northwester state, particularly in Jigawa, Nigeria and thereafter found that, inappropriate waste management was prevalent, a practice that pollutes land, air, water, and ultimately affects human negatively. Similarly, an assessment of solid waste disposal problems in Sokoto town by Ibrahim *et al*., (2019) shows that plastics (especially single use types) are a major waste component that elicits diseases, environmental pollution, and health hazards. Like anywhere in the world, plastic waste disposal is becoming a nuisance in the state. Parable, a study by Shehu *et al*., (2020) upholds the view that, plastic bags (a typical single use plastic) is a problem that cannot be overemphasized in the state. However, the plastics are polymers that are risky all along it its life cycle, because they possessed the ability to affect living organisms, especially humans along all phases/stages of their lives due to their monomers, additives, and sorption chemical properties (Umar *et al*., 2022).

4.2.2 Levels of Copper, And Zinc Found in Plastics

Copper and zinc are among the heavy metals that are in the earth crust. They are needed by the human body at certain optimum amount. Therefore, little amount of copper and zinc in the body is harmful and excess amount of these metals is also harmful to the body. However, the increasing spate of industrialization has led to the more divulge of copper and zinc from the crust into the environment that in turn can expose humans and other biological beings to excess levels of the copper and zinc and in turn toxicity can occur (Munier and Bendell, 2018). Therefore, it is utmost to constantly monitor the levels of these metals in materials such as plastics that might cause pollution at the slightest opportunity. In a related development, locally made plastics for food packaging examined in India has revealed a copper and zinc concentrations of about 1.6 ppm and 1.02 ppm respectively and the metals can migrate into the food items in plastics (Khan and Khan, 2022). Alam *et al*., (2019) in a China study, determined 96 and 154 mg/kg values of copper and zinc respectively in plastic bags from China. This might be because these elements are legally allowed by the government to be included in plastic materials (Alam *et al*., 2019).

However, in a Nigeria study on waste materials in Borno, zinc level of 2.398 mg/L above the recommended level by NESREA was found, despite the ability of copper exposure to cause harm to biological systems (Kolo *et al.,* 2022). Aliyu *et al.,* (2017) studied heavy metals in plastic bottles and sachet in Abuja, Nigeria and observed 206.7 ug/g, and 1048.3 ug/g for copper and zinc used plastics sachets. In a similar vein, a Sokoto study of heavy metals in plastics found peakiest values of 0.901 ppm for copper, and 2.05 ppm for zinc heavy metals in different plastic types in Sokoto that can be in contact with humans or food (Sarkingobir *et al*., 2022). A study from South Africa reported 83.176 mg/L and 0.1610 mg/L for copper and zinc respectively in micro plastics obtained from waste water, therefore, these

metals could be seep to any medium possible or cam be taken by humans when consuming the affected water (Nikosi *et al*., 2022).

4.2.3 Amounts of Lead and Chromium Found in Plastics

Human beings are expected to be exposed to various metals when in contact with plastic materials in a varying degree of concentrations depending on certain factors. Lead and chromium are among the metals that are expected to be found in many plastics because they are deliberately added as additives to maintain some properties of the plastics polymer or sorted as a result of the inherent chemical behaviors of the plastic polymer chain (Godoy *et al*., 2020; Fan *et al.,* 2021). A study that involves simulation of the intestinal tract has revealed that chromium and lead metals present in plastics were able to transgress through the membrane and be absorbed by the intestine (Godoy *et al*., 2020). In another study an analysis of heavy metals in a locally made plastic materials utilized for food packaging, the lead; level at high temperature was highest at 1.9 ppm (Khan and Khan, 2022). A Canadian study that exposed plastic debris as a source of heavy metals to coastal system found highest lead concentration of about 66667 ug/g that can serve as a source of the metal in the coastal area (Munier and Bendell, 2018). Moreover, a study of certain heavy metals in plastics bags famous single use plastics carried out in China found lead and chromium as the most concentrated metals in the observed plastic types (polyethylene, high density polyethylene, low density polyethylene, and polyvinyl chloride); with 71, and 74 mg/kg respectively (Alam *et al*., 2019). Likewise, a South African study that quantifies the levels of heavy metals in microplastics of waste water, revealed zinc, copper, and arsenic not lead (Nkosi *et al*., 2022). Some other types of plastics such as Ep-waste (electronic television) were analyzed in the southern part of Nigeria for heavy metal determination; and 2.79 and 3.26 mg/kg were the recorded values for lead and chromium (Okenwa-Ani *et al*., 2019). However, a study from Northern Nigeria, particularly from Abuja subjected different plastic bottles and sachets for heavy metals analysis and found lead of 1048.3 ug/g among other metals in used virgin plastic sachet (Aliyu *et al*., 2017). Nevertheless, lead and chromium were determined in Sokoto in samples of some plastics; therewith, 0.0700 ppm, and 0.540 ppm are the elevated levels of lead and chromium determined respectively (Sarkingobir *et al*., 2022).

4.2.4 Consequences of Elevated Levels of Heavy Metals Found in Plastics and Ways of Prevention

The consequence of high levels of heavy metals in plastics cannot be overemphasized. Adeyi *et al*., (2019) upholds the view that, heavy metals in plastics observed in Lagos could pollute the soil, water, and in turn be taken in by plant for upward delivery into the food chain. The humans are the ultimate consumers as well (Adeyi *et al*. 2019). A study from Bayelsa Nigeria on possibility of contamination of beverages made locally and sold in plastic containers, reiterated that there is every possibility of contamination of the beverages due to high heavy metals (Seiyaboh *et al*., 2020). An Abuja study by Aliyu *et al*., (2017) had demonstrated the ability of plastics to sorp heavy metals due to pollution, hence could be transferred to food, water, air, or other components of the environment that in turn affects.

Certainly, there are among the community of metals some that are essential to the human biological system such as zinc and copper; others can cause toxicity even at little concentration (such as lead and cadmium) (Witkowska *et al*., 2021). Likewise, even the essential heavy metals like zinc and copper can elicit adverse outcomes when taken in excess amount by the human body. Exposure to excess xenobiotic such as heavy metals under abnormal condition can elicit effects such as on the gastrointestinal, reproductive, respiratory, renal, neurological, and other systems of the body. Some of the heavy metals can cause cancers due to their ability in triggering oxidative stress, lipids and proteins destruction, and DNA destruction as well (Benson *et al.*, 2017; Adeyi *et al*., 2019; Witkowska *et al.,* 2021). Consequently, since high reveals of heavy metals could be transferred to the food, water or be absorbed in the environment by plants for

ultimate shuttle in the food chain and the metals could trigger devastating consequences, there is need to seek for ways to address the issue squarely (Khan and Khan, 2022). Adeyi *et al*., (2019) call for proper waste management, because improperly managed waste subject the soil or water to too much heavy metals (such as lead, cadmium, and chromium) and only used some of them (such as copper and zinc) at little concentrations; these metals have to be deposited in plants parts. Consequently, the humans that cannot make their own food, rather relied on preformed food materials mostly from plants have to ingest much heavy metals and be affected (Adeyi *et al.*, 2019; Alam *et al*., 2019; Okenwa-Ani *et al*., 2019; Njoga *et al.*, 2020).

4.2.5 Some Remedies or Solutions for Prevention of Plastic Pollution

There are several solutions to control the consequences of plastics. Some of the solutions are identified below:

- Ban unsafe, untested use of plastics. Unsafe, untested nanoplastics should be avoided from human or environment
- Conduct a full-lifecycle environment, health, and safety assessment before commercialization (Natural Resources Defense Council, 2007)
- Restriction of additives. Parable, bisphenol A is about to be banned in Europe, it has been banned from baby bottles. Phthalates has been restricted in EU from certain plastic products
- Knowledge gap should be filled through extensive research, and development of appropriate technologies for risk assessment. Heavy metals should be ban from plastics that are in contact with food (Science for Environment, 2011; Anumol, 2019).
- Biotechnology use. It involves using microbes or microbial enzymes to treat plastic waste. Typical microbes are Pseudomonas, Flavobacteria, Arthrobacter, Agromyces (Ogunola, 2017)
- Cleaning up- Plastic waste environment should be cleaned
- Behavioural change- There is need for extensive awareness creation, so that leaders become truthfully committed to address plastic threats. The public should fully be educated to know the pros and cons of plastics, and act positively, also forced governments to act well (Ogunola, 2017)
- Taxation- Increased taxes for plastics is a step to reduce plastic use. It will lead to hike in price, and low production and low patronage (Sarkingobir *et al.*, 2020).

4.3 Models for better Comprehension of Heavy Metals in Plastics and Effects on Human

Metals are found in the earth crust and are expunged due to human activities. A major human activity is the industrialization of plastics that contains heavy metals and due to the unique contact of plastics with humans they are exposed to heavy metals along the way in different doses (Balali-Mood *et al.*, 2021). There are several models that are of importance in understanding the behavior of metals and possible effects in humans. Some of them and their applications are listed below;

"Molecular mimicry or ionic mimicry" phenomenon that entails that some metals mimic the behavior or action of others thereby competing with them and in turn inhibiting their actions (Balali-Mood *et al.*, 2021). For example, cadmium mimics zinc and calcium metals. This model is applicable in understanding the effects of heavy metals in plastics, because several works have depicted that, plastic leaches it additives such as heavy metals into contact materials such as food wrapped by plastic, water contained in a plastic bottle, beverages contained in a plastic bottle etc. Therefore, upon eating the food by the humans, the metals are delivered and absorbed along with the food. Absorption of metals such as cadmium behave like zinc (a useful metal by about 200 enzymes of the biological system), and outcompeting the zinc and

inhibiting the processes that are performed by zinc containing enzymes. Ultimately, the effects manifest in the body (Balali-Mood *et al.*, 2021).

"M1: Bioaccumulation and Toxicokinetic Model (TK Models)"

Metals can neither be created no destroyed, rather can be transformed from one form to the other. Hard metals (hard acids), which are the weakest toxic; preferably bind with hard bases that contain oxygen, forming weaker bonds with soft nitrogen and sulfur species. These binding capacities are form in the body to cause adverse effects (Witkowska *et al*., 2021).

"M2: Dietary Exposure Models"

In this model, plants absorbed metals from soil and deposit excess essential and little non-essential metals for the humans (consumers) to take in along the food chain (Balali-Mood *et al*., 2021). Therefore, according to this model, the plastics in contact with food such as biscuit wrappers, take away containers, water bottles, beverage bottles etc. are the subjects that contains additives such as heavy metals that under certain conditions such as heat, pressure, Uv rays, microbial actions, etc. allow the metals to seep from the plastic polymer complex into the foods item. Consequently, when humans take the diets the heavy metals are taken up simultaneously (Witkowska *et al.*, 2021).

5. Conclusion

Nowadays, industries have supported the human endeavors by producing plastics as synthetic chemicals. However, plastics contain metals as additives or adherents, that are induce to contaminate soil, water, and food. Therefore, use of plastics should be drastically contain in order to reduce the prevalence of chronic health effects among populations.

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