Water Pollution And Man's Health

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Abstract

Industrialization and technological development processes have led to the introduction of hazardous chemicals into the environment — water, air and land. These have increased the number and level of dangerous chemicals such as environmental pollutants (heavy metals), agrochemicals (herbicides, pesticides, halogenated polycyclic hydrocarbons), sewage wastes, food additives and other allied contaminants, thereby, exposing man and animals health wise. The dangers and health hazards caused by the above pollutants can be reduced by the use of microbial degrading enzymes and natural plant products proved to have cytoprotective properties against the free radicals generated by the harmful pollutants. This presentation has highlighted the above with particular emphasis on water pollution and man's health and opined by way of recommendation that proper and efficient environmental policies which will emphasize on proper disposal of industrial and sewage wastes can serve as additional panacea to the problems created by water pollution to man's health.

INTRODUCTION

Pollution is the introduction by man into the environment of substances or energy liable to cause hazards to human health, harm to the living resources and ecological systems, damage to structures or amenity or interference with legitimate uses of the environment. Pollution had always been misused for contamination which can be defined as the presence of elevated concentrations of a substance in the air, water, soil or any other such thing not necessarily resulting in a deleterious effect. Water pollution, therefore, is the direct or indirect human introduction of substances into the water environment such as to harm living resources, affect human health by various cytotoxic and infilterative disorders and impair water environment quality.

THE ORIGIN OF POLLUTION

The word pollution is difficult and notorious to define. The Latin word pollere – to soil or defile provides little help and pollere could also mean contamination of any feature of the environment (Glenn and Toole, 1997). Industrialization and technological advancement/development processes have led to the introduction of hazardous chemicals into the environment (water, air, sea, lake, atmosphere land/soil). These chemicals include the following: environmental pollutants, heavy metals, agrochemicals, herbicides, pesticides, halogenated polycyclic hydrocarbons, food additives and other allied contaminants and sewage wastes.

Any definition of pollution should take the following important points into account:

1. Pollution is not merely the addition of a substance to the water environment, but its addition at rate faster than the environment can accommodate it. There are natural levels of chemicals such as arsenic and mercury in the environment but only if these levels exceed critical values can they be considered pollutants.
2. Pollutants are not only chemicals. Forms of energy like heat, sound, and &- particles, ? – particles, ? rays and X – rays may also be pollutants.
3. To be a pollutant, a material has to be potentially harmful to life – some harmful effects must be recognized (e.g. irritants).

The impact of pollution on the environment: Pollution x affluence x technological development (Meadows et. a.l. 1992). The combined effect of population, affluence and technology are the factors responsible for pollution and other types of environmental degradation. Pollution arose as a result of technological development.

The first major oil pollution incident in UK was in 1967. 120,000 tonnes of crude oil was washed upon many cornish beaches. The effect was that sea birds could not fly because oil coated their feathers. The result was hampering of insulatory properties, death and hypothermia. Sea weed

couldn't photosynthesise. Gills of fish were covered, no feeding and no respiration. This also caused termination of most of the fish.

Over 60,000 chemicals are in common use while up to 500 new ones are introduced to the commercial market annually. Similarly, the production and use of energy, production and use of industrial chemicals and increased agricultural practices have had a deleterious effects on water affecting man's health generally and specifically.

CLASSES OF POLLUTION

Pollution can be classified based on transport media as air, water and soil.

AIR POLLUTION

This can be defined as any gaseous or particular matter in the air that is not normal constituent of the air or is not normally present in such a high concentration. Air pollution is one of the most difficult to control because it poses international and national threat. The pollution in air can be caused by burning fossil fuels e.g. oil, natural gas and coal as well as those released everyday by vehicle exhaust such as Carbon monoxide, oxides of nitrogen and hydrocarbons such as ethane and methane (CO, NO_2, NO_3, C_2H_4, C_2H_6, respectively).

Two other types of pollution have been classified. The first is characterized by SO_2 and smoke from incomplete combustion of coal and by conditions of fog and cool temperatures. This is termed the reducing type of pollution because of its chemical nature. The second is characterized by hydrocarbons, oxides of nitrogen and phytochemical oxidants and because of the meterological inversion layer, it is described as an oxidizing type of pollution or phytochemical air pollution.

LAND SOIL POLLUTION

Land pollution does with the terrestrial environment which extends from the top of the growing vegetation to the capillary fringe of groundwater which is the primary home of most living things on earth. Land pollution is the introduction of harmful chemicals into the environment to grow and increase food supply, to protect man and his crops from pests and diseases and dispose off wastes. Unintended entry also occurs through transport accidents, inaccurate or inappropriate application procedure and leaking sewage facilities. Because the chemicals and other living things share the environment, this can lead to significant exposure to the chemicals and therefore, resulting in detrimental health impact. The rains carry non – degradable pollutants and wastes into groundwater, nearby streams and the soils too.

The wastes in the landfill can also decompose under heat and pressure of the soil above releasing harmful gases like methane (CH_4).

WATER POLLUTION

Water pollution becomes most obvious when it involves poisoning of drinking water or causes the death of a large number of fish or other aquatic population. This could be caused by sewage. Disposal of sewage wastes into a large volume of water could reduce the biological oxygen demand to such a great level that the entire oxygen may be removed. This would cause the death of all aerobic species – fish.

Some toxic chemicals released into the rivers and seas such as Pb, Cu, Zn, Hg, CN will cause the death of fish, algae and lesions in human beings even at very low concentrations. These are related to occupational hazards and constitute elements of environmental pollution especially with respect to pollution by heavy metals. Such incidents had been reported in the past. For example, the Minimata and Niigata epidemics in Japan in 1950s and 1960s respectively. The Minimata epidemic was a case of mercury poisoning caused by consumption of fish from the Minimata Bay of Japan which was heavily contaminated by mercury compounds discharged by a nearby plastic industry. This epidemic occurred during 1953 – 60 and was the 1 st serious outbreak of Hg poisoning. It was characterized by severe damage to the nervous system leading to ataxia, paraesthesia (abnormal pricking sensations), loss of vision and hearing and ultimately death. The primary pollutant was inorganic Hg, but an organic derivative, methyl mercury was found in the fish. This was converted by methylation through the microorganism in the water, fish gut, mud or all. Organomercury compounds being lipid soluble have very high affinity for cellular lipids and therefore accumulate in lipids of nervous tissues (Okoye 1992). This was a typical case of metabolic activation giving rise to a toxic metabolite.

Three forms of mercury pollute the environment:

1. Metallic mercury – this is excreted in urine mainly in the inorganic form.
2. Inorganic mercurous or mercuric ions – Hg forms very stable complexes with the free – SH (thiol) groups of proteins and consequently inhibits

enzymes with – SH at their reactive sites irreversibly.

3. Organo mercury (Hg is part of an organic compound) and remains in organic form in the tissues e.g. hair. The rate of removal of mercury from the blood is very slow. Hg is removed by prolonged treatment of patients with an appropriate mercury ion chelator like N – acetylpenicillamine.

The second case of Hg poisoning was the epidemic of consumption of fish from polluted Kalu River in the Thana district of Bombay, India. The major symptom was paralysis.

Another major epidemic of water pollution was the Itai – itai disease which affected a Japanese population that consumed fish and other foods harvested from coastal waters into which cadmium – containing industrial effluent was being discharged. The disease was characterized by brittleness of bones, muscular weakness and loss of appetite.

Pb poisoning is another serious source of environmental pollution which causes water pollution. Pb poisoning is characterized by CNS damage, anaemia and deposition of Pb in bones and teeth. The major sources of this pollutant are paint manufacturing industries/factories, lead smelting works; petrol engines discharged inorganic Pb salts, metallic Pb and organic Pb respectively. Pb $(C_2H_4)_4$ – is used as an anti knock in petrol engines and is a pollutant. The anaemia caused by Pb is due to inhibition of haem biosynthesis. Inorganic Pb inhibits aminolaevulinic acid dehydratase and ferrochetalase (haem synthetase) which catalyses the formation of the pyrrole porphobilinogen and incorporation of Fe^{2+} into protoporphyrin IX respectively. Pb forms very stable complexes with – SH groups of enzymes. The above is by no means exhaustive. In 1996, there were cases of chromium and cadmium pollution in sediments of Suzhou Creek while cases of metal poisoning were earlier recorded in USA and Britain between 1974 – 1975. The susceptibility of any individual within a group of people equally exposed to a metal toxin varies with age, sex and social habits, such as smoking and alcohol usage.

Organic pollutants contain hydrogen, carbon and oxygen e.g. petroleum products (gasoline, oil, pesticides) solvents, cleansing agents, polychlorinated biphenyls (once used in electrical transformers), human and animal wastes. These also constitute serious sources of water pollution. Some of these pollutants are found to cause cancer and other health effects in humans. They are toxic to fresh water and salt water organisms. Hazardous wastes are potential dangers due to their nature or quantities. They have the characteristics of toxicity, flammability, corrosivity with a high tendency to remain/persist in the body e.g. phenols, arsenic, mercury, lead and a host of others.

IMMEDIATE CONSEQUENCES

1. Crops grown on soils polluted by industrial chemicals accumulate varying concentrations of these chemicals. In the course of absorbing water and nutrients from the soil, plants take up the chemicals. The agrochemicals cannot be degraded because they lack the enzymic machinery to degrade and excrete them. They are deposited in tissues and cellular structures including those of edible parts that are not active in metabolism (Okoye 1992).

2. Aquatic foods harvested from coastal waters, rivers and waterways into which industrial effluents have been deposited contain high levels of these harmful chemicals which induce cytotoxicity in cells.

3. Meat and dairy products from livestock grazing on polluted pastures, drinking polluted water e.g. Hg, Cd, Pb, radioactive materials, complex organic compounds e.g. polycyclic aromatic hydrocarbons and halogenated aromatic compounds. The human body cannot handle these pollutants.

The industrial solvents/chemicals may contain nutrient substances – Mo, Cu, Fe and Zn at very high concentrations.

Some of these associated toxic effects include the following:

- Excessive iron is associated with damage to the inner lining of the gastrointestinal tract while the toxic effects of zinc include heartburn and serious circulatory and gastrointestinal disorders.

THEORETICAL RATIONALIZATION AND CONCEPTS OF WATER POLLUTION AND MAN'S HEALTH

One is at a loss considering the enormity of hazards caused by water pollutants and their toxicological consequences on man's health. Xenobiotic oxidants are discharged into water with the result that oxidative stress is imposed on aquatic organisms (fish, crab, prawn etc). Free radicals are generated

such as those of organomercury, Pb, Cd and the other heavy metals resulting in the peroxidative deterioration of membrane lipids.

Lipids yielding breakdown products like hydroperoxides, peroxyl radicals, endo-peroxides, carbonyls and aldehydes, malonaldehyde, mahendialdehyde and other TBA – reactive species, low molecular weight hydrocarbon gases (ethane and pentane) which are all toxic to cells. Oncogenesis/Carcinogenesis could develop. Cytotoxic enzyme markers such as gamma glutamyl transferase, alkaline phosphatase, acid phosphatase, serum amino transferases, all show-elevated activities.

Physiological Parameters – PCV, HB, RBC status are compromised while WBC proliferates with attendant increased lymphocyte maturation.

Histopathological Lesions – fatty degenerations, necrosis, cirrhosis, destruction of blood vessels and connective tissues occur.

All these are as a result of the free radicals generated from consumption of water pollutants which cause lipid peroxidation of the membranes. If the source of pollution in the water is microbial, the following diseases may ensure:

1. Dysentery
2. Diarrhoea
3. Cholera
4. Typhoid Fever
5. Mycosis/mytoxicosis/Aflatoxicosis–caused by aflatoxins B1, B2, M1, M2 Plamatoxins BO, GO, acetogenins and polyketydes all produced by the ubiquitous fungi,Aspergillus flavus. These have their biochemical effects and are potent oral hepatocarcinogens.

MICROBIAL POLLUTANTS OF WATER AND SYMPTOMS OF INGESTED MICROBIAL POLLUTANTS

Microbial pollutants such as those ellaborated by algal species like cyanobacteria are major pollutants of fresh and salt waters globally right from Europe,North and South america,Asia and Africaespecially the West coast of Africa including countries like Ghana and Nigeria.The toxic cyanotoxins produced have been characterised from many cyanobacteria such as microcystis,anaebena,plankthothrix,oscillatoria,radiocystis and cylindrospermopsis(Sivonen and Jones 1999 ,Senogles-Derham et.al,2003,Vierra et.al,2003).Because of the cyclic nature of these cyanotoxins especially microcystins which are cycli peptides,they are chemically stable and water solluble,thus accounting for their persistence and exposure in the environment.The cyanotoxins can not penetrate easily through the biomembranes and their toxicity is restricted to the liver as their target organ.

The hepatotoxic cyanotoxins produced by cyanobacteria are microcystins,oscillatoria and nodulatoria with diverse inhibitory effects on plants,protozoa,crustaceans and even mammals.Ingested microcystins present with extensive hepatic hemorrage and necrosis,increased liver weight and marked activities of aminitransferases in the plasma as well as lactate dehydrogenase(Runnegar and Falconer 1982,Falconer and Runnerger 1987).Microcystin--YM ingestion causes perilobular necrosis while microcystin--LR causes initial centrilobular necrosis(Falconner,1993);this probably points to the localisation of the enzymes responsible for the reported metabolic transformations.

As mentioned earlier,the liver is the main organ intoxicated by this group of cyanotoxins but there had been other reports of damages of tissues such as abomasum,small and large intestines,as well as the kidney in experimental animal models like sheep,mice and rats.Other reported toxic effects of ingested hepatocyanoginsincluded depletion of hepatic glutathione with little changes in respiration,protein synthesis,DNA synthesis and cell membrane intergrity,depletion of glycogen and dose-response activation of glycogen phosphorylase(Runneger and Falconer 1982,Falconer and Runneger 1987).Earlier diagnosis of patients infected by cyanogin ingestion showed major sympthoms of malaise,anorexia,vomiting,headache,initial constipation followed by bloody diarrhoea and varying levels of dehydration(Byth,1980).The urine sample analysed showed loss of electrolytes with glucose,ketone bodies and proteins being identified.The gastrointestinal tracts,kidneys and livers of treated mice werealso observed to present with wide spread tissue damages(Hawkins et al,1985).The microcystin toxicity is mediated through irreversible inhibition of the 1&2A catalytic sub-units of protein phosphatases.

Apart from the hepatotoxins,neurotoxic alkaloids are produced by neurotoxic cyanobacteria such as anaebena sp,cylindrospermopsis-raciborskii and planktothrix

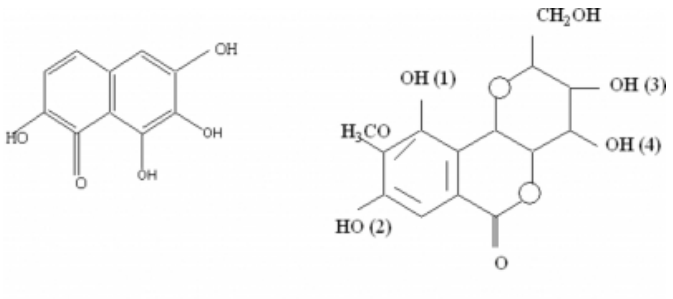
agardhii.some of theneurotoxins classified are anatoxina,saxitoxin and cylindrospermopsin.They represent a broad group of heterocyclic nitrogenous compounds with at least,one C-N bond,usuallyof low molecular weight(Sivonen and Jones,1999).Anatoxin is an inhibitor of anticholiesterase while saxitoxin,a paralytic shellfish poison is a gastrointestinal disease causing agent as well as a sodium ion blocker.The dinoflagellate-induced intoxication of seafoods as well as ciguatera-induced paralytic and diarrhetic effects in fish and shellfish had been documented.

Fatal intoxications of consumptionofwater infected by microcystins as well the cases of gastroenteritis after the appearance of cyanobacteria in drinking water sources in North and South America have not been fully controlled.The only control measure so far is the introduction of stratification in water reservoirs(Addico,2004).

PANACEA

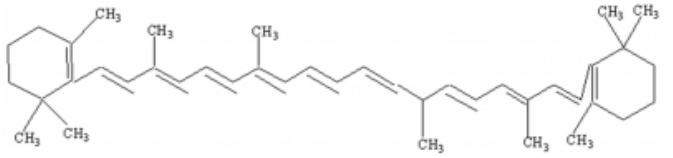
There is a good correlation between low cancer risks/incidence and dietary beta – carotene consumption (Peto et al 1981). Typical antioxidants like alpha–tocopherol(Vitamin E), beta – carotene, bergenin, Vitamins A, C(ascorbic Acid), purpurogallin and eugenol should be sourced from local dietary sources to mop the free radical fluxes (Sugiyama et al 1993, Halliwell 1994, Machlin and Bendich 1987 Maduka and Okoye 2001, 2002, Maduka et al 2001). These compounds are structurally equipped to take part in photosensitivity reactions because they are highly light absorbing. They act as complementary pathways to enzymic pathways, which quench free radicals in the system (Maduka 2002, 2004).

Figure 1

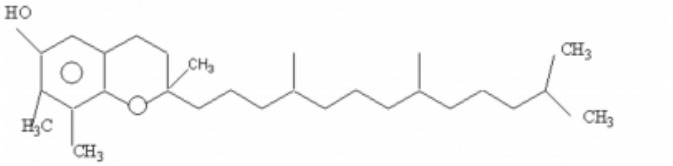


(Structure of Purpurogallin)

Structure of bergenin



(Structure of B-carotene).



(Structure of α-tocopherol)

Natural plant products like Sacoglottis gabonensis stem bark extract, a Nigerian palm wine beverage additive are to be included in formulating dietary regimens (Maduka et al 1999, Maduka and Okoye 2000, 2002, Maduka et al 2003).

ROLE OF MICROBIAL ENZYMES IN THE DEGRADATION OF POLLUTANTS

Oxidoreductases, hydrolases and transferases degrade wastes. Phosphatases, glucosidases, xylosidases, chitinases and sulphatases are induced in biochemical nutrient cycles. In water saturated peat lands, few enzymes are able to degrade aromatic phenolic rings to render the carbon skeleton available to other hydrolytic enzymes. Phenolic oxidase – glucosidase – endo – 1 – 4 – gluconase, cellobiohydrolase degrade structural cellulose to energy rich glucose molecules. Soil mineral content also helps action of glucosidase. Hydrolases degrade pesticides - organophosphorus , pyrethroid and carbamate insecticides, dithiocarbamate dinitrophenol insecticides. Benzenoid, polycyclic and some heterocyclic substances form epoxides which are highly damaging to the cells. These enzymes degrade the epoxides which can act as mutagens and carcinogens.All these pollutants are usually discharged into

streams, rivers, seas e.t.c. Most of them are non-biodegradable in nature e.g dieldrin and endrin.

MICROSOMAL POLYSUBSTRATE OXYGENASE:

The mixed function monooxygenase enzyme complex typified by Cytochrome P_{450} handles detoxification reactions of drug. Glutathione involving glutathione – S transferase is also important in the destruction of carcinogenic oxides (Boyland, 1974). Glutathione – S -- aryltransferases involving a consortium of enzymes are introduced to spill areas to degrade the wide range of complex compounds in crude soil to minor compounds. (Bossert and Bartha 1984, Bink 1981, Gibson 1980).

CONSEQUENCES OF WATER POLLUTION ON THE ECOSYSTEM

Acid rain – wet (rain, snow, and fog) and dry (particulate) acidic depositions that occur and downwind of areas where SO_2 and NO_2 oxides result from burning fossil fuels. Fish disappeared from lakes in Sweden and this was traced to acid rain, result of industrial processes in Germany and Great Britain. Crayfish produce fewer eggs in acid water and the eggs produced often grow into malformed larvae. Acid rain leaches Al, Pb, Hg, Cd from soils and rocks in a drainage basin and discharges them into rivers and lakes.

The metals can clog the gills of fish and cause suffocation. The heavy metals pose health hazards when they are concentrated in fish which are passed on to people, mammals and birds when they eat the fish. Drinking water from acidic lakes too may have high concentrations of these toxic metals.

Ozone Depletion: – UV radiation – leads to a reduction in the primary productivity of the world oceans e.g. loss of productivity of phytoplankton (microscopic marine algae and photosynthetic bacteria that float near the surface of the ocean because of ozone depleted to about 80% over the Antarctic area. The organisms are at the base of the food chain. Increase in global CO_2 concentration – NH_3 is present in effluents and toxic to aquatic organisms. Toxic industrial and organic sewage are to be properly disposed with the government promulgating the necessary laws to ensure they are complied with.

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