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POLLUTION OF THE INTERNAL ENVIRONMENT

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Professor of Pharmacology,
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An Inaugural Lecture delivered on 18th February, 1971 at the University of Ghana, Legon.

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I INTRODUCTION

Public Interest

POLLUTION of the external environment is a popular subject. It is of interest to journalists, politicians, youth groups and royalty. The subject is kept alive by many societies. Thus in the United States we have

The American Shore and Beach Preservation Association
The Game Conservation Society
The Isaac Walton League of America (Fish)
The National Audobon Society (Birds)
The Soil Conservation Society of America
The Wild Flower Preservation Association

But with respect to pollution of the internal environment, the only well known American society is the Temperance League of America (1). Perhaps this is because the person who pollutes the commons inconveniences others while the person who poisons himself, as a rule, does not endanger others.

The Crusaders

There are many popular articles dealing with pollution of the earth. One of these quotes from the Bible (2): "The earth is drooping, withering — and the sky wanes with the earth for the earth has been polluted by the dwellers on its face" (Isaiah 24:4–6) and "Even the beasts and birds and the very fish within the sea are perishing" (Hosea 4:1–2). The most exhaustive and dramatic of these publications is "Silent Spring" written by Rachel Carson in 1962 (3). This book deals with pollution of water and soil and its effects on various forms of life. The author seems to feel that the synthetic chemist is nature's worst enemy. Although she cites instances in which man himself has been poisoned by pesticides or herbicides, she is deeply concerned with the preservation of wild life and the aesthetic characteristics of the environment (2). A more up to date presentation of the subject is given in a recent issue of the National Geographic Society Magazine (4).

Apparently reptiles, birds and mammals, that live on land, are better equipped to deal with lipid soluble toxins than most fish, being able to increase the polarity of the chemical, rendering it more soluble, and thus hastening its rate of excretion as in the case of DDT (9). Nevertheless some birds are quite vulnerable to DDT and other poisons because of their high metabolic rate and peculiar mineral metabolism.

II. POLLUTION OF THE EXTERNAL ENVIRONMENT

Cause of Increased Pollution

Pollution of the external environment includes pollution of the air, pollution of the soil, pollution of fresh water, pollution of the seas and finally contamination of the plants and animals that live in these environments. Pollution of the external environment is largely the result of increased density of population, increased industrial development, increased level of production and consumption coupled with a lack of interest, concern or control over the effect of civilization on the environment. Some authors associate the increased level of material wealth and the decreased interest in nature with a lack of morality. Certainly many of the abuses which lead to pollution are connected with the desire to make the greatest profit in the shortest time.

Air Pollution

In Britain the Government has done much to reduce the extent of pollution of the external environment, especially pollution of the air. "Until about 1956 dense fogs containing smoke and other pollution from burning of coal used to occur from time to time in London and other centres of population. Since then, as a result of changes in fuel usage and the operation of clean air legislation fogs have become less severe" (10).

Soil Pollution

With regard to pollution of the soil, in many countries the use of DDT is restricted while in some countries it is prohibited. In the developing countries there is much less control over DDT. With respect to herbicides there are even fewer restrictions.

Fresh Water Pollution

With regard to pollution of rivers and water supplies, in Britain there are "River authorities" responsible for the control of pollution of rivers and certain tidal waters and approval must be sought before polluting effluents are discharged. The greatest threat to lakes is eutrophication, an overabundance not of poisons, but of nutrients. This upsets the delicate balance between microscopic and macroscopic forms of life because of the competition for oxygen.

Sea Water Pollution

Britain is a party to the 1954 International Convention for the prevention of pollution of the sea by oil. Originally operating up to 50 miles from land, this was extended to 100 miles in 1962. As of 1965 the Convention prohibits ships of 20,000 tons and over from discharging persistent oil anywhere at sea. Mercury and DDT are also potential sea water poisons.

The Vicious Cycle

Ionizing radiation, smog, and the wanton use of herbicides have a systematic effect upon plant life. First the most sensitive trees, such as pines, die out, then the other trees are replaced by shrubs and herbs. These are then replaced by herbaceous weeds, only the most resistant species surviving (11).

A similar order of precedence occurs with animal life. The first to disappear are the carnivorous birds such as hawks, eagles, herons and the peregrine falcon. Other birds such as crows and sparrows remain. One would expect a similar pattern in the sea. Even in the backyard, the fine green carpet suffers while crab grass can take over. Thus the accumulation of chemicals, accidentally discharged, or put into the environment to reduce unwanted forms of life, may lead to an increase in other plants and animals which are even less desirable.

III POLLUTION OF THE INTERNAL ENVIRONMENT

Introduction

The lung tissue may be affected by inspired toxins. The skin may be affected by contact with toxic agents. Whether absorbed through the lung, the skin or the digestive tract some poisons enter the body and are distributed via the blood stream. The noxious agent may be stored up in fatty tissues, the bones, the nails and hair, or the reticulo-endothelial system. Finally the noxious agent may damage a particular organ or tissue such as the blood or the nerve endings.

Furthermore a combination of two or more toxic agents may be more harmful than either one alone. Thus, with many drugs, the ingestion of alcohol is dangerous. On the other hand, the ingestion of one toxic agent may mitigate the toxic effects of a different agent. The mechanism of this action has been elucidated in the case of sleeping pills containing barbiturates. Barbiturates induce the microsomes of the liver to manufacture increased amounts of an enzyme that attacks alykl chains attached to aromatic rings. Since many drugs and poisons consist of aromatic rings with alkyl side chains, they are more quickly detoxified by the individual who is taking barbiturates (12).

The Lungs

With respect to lung tissue the two types of pollution that occur most often are contamination of the inspired air by industrial smoke and contamination of the inspired air by smoking tobacco. The most serious consequence of such contamination is the production of bronchogenic carcinoma. The incidence of this tumour is twice as high in city dwellers as in people who live in rural areas. But the incidence of lung cancer is more than ten times as high in smokers as compared with non smokers. Emphysema and bronchitis are six times as common in smokers, cardiovascular diseases twice as frequent (13).

Because of the large amount of revenue which governments gain from the sale of tobacco, in addition to the profits of this

huge industry and the importance of tobacco in certain agricultural areas, it is difficult to take any action that would reduce the smoking habit. In the United States, radio and television advertising of cigarettes has just been banned. It has been suggested that cigarette packages bear a warning that smoking increases the hazard of developing cancer.

Contact Poisons

It has been known since 1775 that exposure to soot is associated with cancer of the scrotum because of its high incidence in chimney sweeps. It has been found that 3, 4 benzypyrene is the major coal tar carcinogen and furthermore that this property is associated with a high electron density at the 3, 4 double bond which facilitates fixation to tissue protein (14).

Poisoning with insecticides is often the result of skin contact with an oily solution, spray or powder.

Prolonged exposure to sunlight, especially in fair-skinned individuals predisposes to the development of skin cancer. More important is exposure to ionizing radiation. Apparently radiation seems to have both initiating and promoting effects on malignant growth.

Whether the radiation is caused by isotopes or x-rays, the malignancy can be internal, and in the case of leukaemia, there is a close dose effect relationship between the amount of radiation and the incidence of the cancer (15).

Poisons That Localize in Fatty Tissues

Some chemical substances are deposited in the fatty tissues whether they are taken by mouth, absorbed from skin, or injected intravenously. Localization in the fatty tissues renders the substance less toxic to the body as a whole. This explains *in part* why insecticides like DDT are less harmful to the human than to insects and fish. Another reason why DDT is less toxic to humans is the existence, already explained, of a system for its degradation and excretion.

Although in some countries the use of DDT has been banned a compromise has been *recommended* in the United States (16).

(1) Indiscriminate use should be stopped and research in non-chemical methods of pest eradication should be expanded

(2) Use of DDT should be continued for the control of diseases transmitted by DDT susceptible vectors when less harmful control measures are ineffective.

(3) Use of DDT should be continued for the control of pests on crops when no adequate alternative is available.

(4) Use of DDT should be discontinued in areas where its use has created a serious problem for the survival of wild life, etc.

Poisons that Localize in the Bones

Normal bone contains calcium and a small amount, 1/300 as much of strontium. Under abnormal conditions lead, radium and radioactive strontium are also deposited in bone. The best treatment for lead poisoning used to be the administration of calcium, phosphate and vitamin D which hastens the deposition of the metal in bones where it does not affect the vital processes. Now we have a chelating agent (EDTA or) ethylenediaminetetra-acetic acid which combines with lead and is rapidly excreted from the body.

Radioactive strontium which has a half life of 28 years and an effective half life in the body of 7 years (17) is the most important radioactive contaminant of the atom bomb era. If the proportion of strontium in bone that is radioctive were to rise above the present level it might become a serious menance to the bone marrow where blood is formed.

Food Poisoning

We are all familiar with poisoning due to bacteria, and their toxins, whether ingested along with food or water, and this topic will be left to the microbiologists. However there may be poisoning of food or water with non-living chemical substances. Some foods themselves can be toxic such as fava beans, chick peas and certain varieties of manioc. Some foods become contaminated, during growth or harvesting, with fungus (aflatoxin), senecio alkaloids, argemone oil (18) etc. Some foods or beverages are adulterated with toxic substances such as methyl alcohol. Sometimes toxic

substances are inadvertently added to the food. Sometimes the vessel used in cooking or storing the food causes metal poisoning. Finally, mention must be made of the possibility that some of the food additives or preservatives, intentionally put there, may have deleterious effects. In this class are hormones used to feminize roosters and antibiotics used to increase the weight gain of cattle, pigs and poultry.

Recently people have reported numbness and tightness of the facial muscles, especially those required for chewing, after eating in Chinese restaurants. Originally thought to be due to the large amount of sodium ingested, these symptoms have now been shown to be due to the large amount of glutamic acid. Apparently some people are more susceptible than others to the effects of monosodium glutamate (19). Furthermore this chemical substance causes brain damage when fed to new born mice. As a result it is no longer used as a food additive and only sparingly in the preparation of Chinese food.

Saccharin has been used for many years as a substitute for sugar in diabetics and individuals suffering from overweight. Recently it has been shown that injections of saccharin can cause cancer in rats. But diabetics who have taken saccharin orally for many years have not shown any more cancer than people not given this substance. Although saccharin could not be introduced as a food additive according to our current standards, its long use in man has proved that it is innocuous for this species when taken by mouth. On the other hand, sodium and calcium cyclamate have been banned as food additives following the discovery of bladder tumours in rats fed with this sweetening agent (20). Cyclamates are one tenth as potent as saccharin and must be given in ten times the amount, thus adding to the risk of toxicity. Furthermore, there is a tragic history of numerous deaths from cancer of the bladder in workers exposed to naphthylamine. The latent period for the development of these tumours was 15-20 years (21).

Medications

Medications prescribed by doctors are sometimes responsible for certain unfortunate events due to predictable or unpredictable toxic effects of drugs. The worst example of this occurred when the drug thalidomide was introduced into Europe. Except for a

few neurologic disturbances the drug seemed quite harmless to individuals to some of whom it was given to counteract the nausea and vomiting of pregnancy. However, when this drug was taken between the 21st and 36th days of gestation, the infant was often born with one or more deformed limbs (20). In all some 10,000 children were affected, despite the fact that the drug was withdrawn from the market as soon as its teratogenic effect was discovered.

The herbalists, too, sometimes prescribe potions that are capable of producing toxic effects. In India, the Carribean, and in Africa there are concoctions known as bush tea. These contain leaves of Crotalaria, Senecio or Heliotropium. The active ingredient is a pyrrolizidine alkaloid. A combination of malnutrition and ingestion of bush tea produces veno-occlusive disease of the liver (23). This causes a type of cirrhosis which may facilitate the development of primary carcinoma of the liver (hepatoma) (23). Further the alkaloid can act as an alkylating agent (24) which makes it a potential carcinogen.

IV. INSTANCES OF POISONING IN GHANA

Carbon Monoxide Poisoning

Dr. A. J. Hawe has described eight people whom he attended in Sekondi, Saltpond and Kumasi who suffered from carbon monoxide poisoning, three of the cases being fatal. He drew attention to another instance in the Volta Region where a similar accident occurred (25).

A charcoal brazier or coalpot is used for cooking outdoors. But when the weather is cold and wet, this coalpot may be brought indoors for cooking or for heating. When it is used for heating the windows and doors may be closed, and then there is an accumulation of carbon monoxide in the air.

The occupants of the room may fall off to sleep or develop coma. In some instances vomiting precedes the coma and an erroneous diagnosis of food poisoning is made. The correct diagnosis is suspected when blood is taken as it has a peculiar pink colour due to the presence of carboxyhaemoglobin which can be identified by spectroscopic examination.

Arsenic Poisoning

Dr. E. Sandi and C. G. Farmilo made a study in Prestea, a gold mining community (26).

Apparently some 1,200 tons of ore are roasted, yielding 4 tons of arsenic daily. No attempt was made to eliminate this pollution of the air, even the practically pure arsenic trioxide deposited on the bottom of the smoke stacks being fed back into the roasting system until all the arsenic was dispersed into the air.

Well water contained less than 1/10 part per million of arsenic but rain water collected in the area contained up to 6 parts per million of arsenic, creek water up to 80. Vegetation in the area contained up to 170 parts per million of arsenic and in the dry matter up to 6,000 parts per million. The contamination of plants was restricted to an area of 40 miles from the refinery. Urine samples from persons living in Apentu showed up to 2 parts and hair samples up to 500 parts per million of arsenic.

The residents of the area complained of "black skin disease" physical weakness, defective vision and pain in the eyes, chest, or head. In fact the symptoms were so severe that some individuals abandoned the area (26).

Contact Poisoning with Parathion

Dr. E. Kuma has seen two cases in Accra in which infants have been severely poisoned with parathion. A case was reported of an 8 months old girl (27). An older child had sprayed the baby with a Rhodiatox carton. Fifteen minutes later the mother saw the powder on the baby's face and washed it off but some hours later the baby began to vomit and cough.

When brought to the hospital four hours after that the child had fever, a rapid pulse, very rapid breathing, twitching, sweating, salivation and extremely constricted (pin point) pupils.

An adult dose of atropine was given every hour and in less than 12 hours the child recovered consciousness.

A more specific antidote for organic phosphate poisoning is the drug pralidoxime which regenerates the choline-esterase that has been inactivated by parathion. Atropine merely blocks some of the actions of acetylcholine which accumulates in the body when choline-esterase is inactivated. Unfortunately there is no

pralidoxime available in Ghana despite the fact that organic phosphate insecticides are sold for use in the house as well as in agriculture.

Poisoning with Gammexane

R. W. W. Kay, G. G. Kuder, W. M. Sessler and R. A. Lewis reported on ten persons who ate a meal contaminated with benzene hexachloride (28). The food, touzoffi, contained about 4 per cent of the insecticide, so that the adults must have eaten about 20 grammes of benezene hexachloride.

Two adults and one child died, within 7 hours of partaking of the meal, in coma after experiencing convulsions. Most of the others who had eaten the same food vomited soon after eating. Those that survived the first 7 hours recovered with symptomatic treatment.

It was concluded that in the preparation of the tuozoffi a large amount of maize (corn) meal had been mixed with a small amount of concentrated (25–50%) gammexane which has the same appearance as cassava meal.

Mercury Poisoning

Although mercury poisoning used to be an industrial problem it is now of rare occurrence. However, a serious outbreak occurred in Ghana in 1967, and was studied by F. T. Sai and L. K. A. Derban (29).

Children were attacked with a severe, bloody diarrhoea accompanied by dehydration and weakness, and in some instances neurological disturbances. The epidemic was originally thought to be due to anthrax. After some twenty persons had died, the newspapers reported the epidemic and the health authorities instituted an investigation. The latter was hampered by the fact that the poisonous material had been illegally acquired.

Nevertheless, it was ascertained that some 800 pounds of maize dressed with ethyl mercuric chloride from a State Farm store had been sold to villagers at a very cheap price. Apparently it was known by some of the consumers that the maize was contaminated so that it was first washed with warm water and then made into porridge (akasa) or a dough (akple) and eaten with soup or stew.

In the village investigated, 144 out of 250 persons reported sick, 20 died and 12 were hospitalized for a prolonged period.

The major clinical findings were abdominal colic, headache, fatigue, diarrhoea and vomiting. However some cases showed stomatitis and some exhibited paralyses. Levels of mercury in the urine ranged from 200–930 microgrammes per liter.

According to the report, the symptoms did not arise until 5–14 days after ingestion of the contaminated food and children were more affected than adults. The delay in onset of symptoms may have been due to the organic binding of mercury or to ingestion of repeated meals containing the poison. Neither of the chelating agents, dimercaprol nor pencillamine were available for treatment.

Manioc (Cassava) Poisoning

Throughtout the tropics cassava is a staple food, especially in areas where the soil or climate is unsuitable for growing maize or rice. The tuber of the plant, *Manihot utilissima* is covered by a skin which contains cyanogenetic glycosides and an enzyme which can liberate the prussic acid. Apparently there is wide variation in the amount of cyanogenetic material in different varieties of the plant (30).

M. O. Lamptey has reported an outbreak of food poisoning caused by the ingestion of *kokonte* (dried cassava). In all some 31 people were affected, suffering from abdominal cramps, watery diarrhoea, nausea and vomiting (31). All survived and only one required hospitalization. Cyanogenetic glycosides were found in samples of the *kokonte*.

In Ceylon the health authorities have advised several steps to avoid the toxic material from the peel entering into the final product. The measures advised are rejection of bruised tubers, careful peeling, boiling with an adequate amount of water in an uncovered vessel and discarding the cooking water (32).

A more insiduous type of cynaide poisoning due to ingestion of large quantities of cassava over a long period has also been described (33). The symptoms resemble the neurological disturbances of pernicious anaemia, a disease which results from faulty absorption of vitamin B_{12}. In the extreme form there is optic atrophy, nerve deafness and lesions of the mouth. Apparently the true vitamin B_{12} is hydroxy-cobalamine and the cyanides convert it

to a less effective compound, cyano-cobalamine. Furthermore, it has recently been shown that the most effective treatment for cyanide poisoning is injection of large amounts of hydroxy-cobalamine (34).

Haemolysis in Primaquine Sensitive Individuals

There are over a hundred million people in the world with an inherited deficiency in the red blood cell enzyme called G-6-P D (or glucose-6-phosphate dehydrogenase). These people are especially sensitive to certain foods (fava beans), certain drugs (sulfonamide) and certain poisons (naphthylene). They also develop unusually intense jaundice during certain infections and at birth (34).

According to the results of some 10,000 tests in our laboratory the frequency of the enzyme deficiency in Ghana is approximately 15 per cent. A case has been reported of a medical student treated with the drug, furadantin. After 5 days of treatment he developed back pain and dark urine. Although he was known to have a deficiency in the enzyme, the drug was continued and he then developed pallor and jaundice. At this stage he interrupted (36) the treatment and made a gradual recovery.

Moth balls are made of the chemical substance, naphthylene. This produces a severe haemolytic anaemia in patients with G-6-P deficiency. Fatal cases have occurred here in Accra. Children have swallowed moth balls by accident and adults have taken them as a medicine. This practice probably dates back to the days when moth balls were made of camphor, still used by the laity as a drug.

Drugs of Abuse

Included in this category are tobacco, alcohol and marihuana or Indian hemp. Having discussed the dangers of smoking there is little to add except that, although cancer of the lung is rare in Ghana, the Pathology Museum of the Ghana Medical School contains a lung removed from a male Ghanaian aged 42, who was a heavy smoker, and who died on 20th May, 1970 of cancer of the lung (37).

Concerning the abuse of alcohol it is difficult to give precise figures. However almost one per cent of sudden, unexpected and unexplained deaths in Accra were found to be due to acute alcoholism (38). Furthermore, it is well known that the ingestion of

alcohol is frequently an important contributory factor in the development of cirrhosis of the liver, a condition which in itself may prove fatal and which may also predispose to the development of primary cancer of the liver. Excluding viral and amoebic hepatitis, diseases of the liver accounted for about five per cent of deaths in Accra during the year 1965–6 (38) and chronic ingestion of alcohol may have been a contributory factor in some of these cases.

According to recent investigations in North America it was found that 70% of drivers killed in single vehicle accidents and 50% of drivers killed in multiple vehicle collisions had been drinking (39). The role of alcohol in automobile accidents is only one of the problems associated with alcoholism that should be investigated in Ghana.

According to F. K. Amarquaye (40) Indian hemp is not infrequently used in Ghana. The wee is smoked by people of all ages but especially young men. According to our studies only 17 per cent of medical students have used it whereas over 50 per cent have taken amphetamines (41). The chief incentive to drug taking is the desire to improve intellectual performance. Fortunately, in Ghana, the use of marihuana does not appear to be a stepping stone to opiate addiction which is the main reason for the strict ban on the use of marihuana in other countries. Whereas there are practically no taboos against the use of alcohol or tobacco, there are very strict regulations against cultivating, supplying, possessing or smoking Indian hemp, the sentence for first offenders being at least 5 years imprisonment.

V. CONCLUSION

It would seem that the time is rapidly approaching when a "Poisons Centre" (42) should be created in Ghana. Such a centre would disseminate information, keep records, and endeavour to see that the necessary antidotes are available. The Ministry of Health and the Ghana Medical Association may wish to participate in such an endeavour. Certainly, the Pharmacology Department of Ghana Medical School would be glad to co-operate. Perhaps University research could be oriented towards some of the problems that have been raised.

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