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your copy Peter *

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TO: Roly Coppack/Dave Wilson/Rob Faulkner/Ray Gomez/Fred Krause

FROM: Peter Lloyd, Geon Vinyl Division.

DATE: Wed. 28th. October 1992

SUBJECT: CHLORINE - THE FACTS

Here is our "authorized version", in response to the Greenpeace document "Chlorine : The product is the poison - the case for a chlorine phase-out".

Ray Gomez is going to put it into a format suitable for publication, but in the meantime the facts can be used as needed.

I have all the referenced documents and can send xerox copies to anyone who is challenged on the facts - except, of course, for the books and Code of Federal Regulations, which are simply too big.

As you know, the Chlorine Institute is funding a major refutation of the Greenpeace Chlorine Report. This refutation - the Cantox study - is being prepared in Canada. It should be highly credible, but will probably not be ready until towards the end of the first quarter 1993.

In the meantime, use this.

I hope you like it, and find it useful.

Peter

Peter Lloyd

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* & thanks for your help! P.

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CHLORINE - THE FACTS

INTRODUCTION

Chlorine is not "a human invention", nor is it "foreign to nature", and it is most certainly not "the Devil's element". It does not have toxic or harmful properties which are unique among the rest of the elements. On the contrary, it is part of life itself, and essential to the working of the human body. Mankind has learned how to make it safely, and how to use it to make many products which contribute to the health, safety, economic benefits and convenience of our lives.

If we attempt to become "Chlorine free by '93" - or even by 2093, we will not be able to support our present planetary population level, and life will be harder, shorter and far more expensive for those who survive. Shutting down the chlorine industry would not eliminate chlorine or its compounds from the environment, because millions of tons of chlorinated chemicals are introduced into our environment every year by natural processes which mankind cannot control.

CHLORINE: ORIGIN, IMPORTANCE AND PROPERTIES COMPARED WITH OTHER ELEMENTS

Chlorine is one of the naturally occurring elements which make up the universe, our planet, animals and human bodies (1). It is very reactive, and as soon as it is produced it combines with other elements or compounds, so that it is rarely seen in its natural state. Nevertheless, it is essential to human life.

It is common for an element which is essential to life to be almost unknown in its elemental, or natural, state. Some elements which are essential to life are so very reactive that they catch fire and burn vigorously as soon as they appear in their elemental state in contact with air or water. They are highly corrosive to human flesh, and are never seen in nature, e.g.,-

> **sodium**, essential in maintaining the acid-alkaline balance of the body fluids of all animal life (6);
>
> **phosphorus**, essential to animal tooth and bone structure, and to the structure of DNA itself in our genes (3);
>
> **potassium**, an essential element in human body chemistry, for instance, in the operation of nerve and muscle fibers and in balancing cell energy intake and waste removal (7).

Many other elements, which are also essential to life, are not so spectacularly reactive as potassium and phosphorus, but as soon as they appear in their elemental state, they react with other elements or compounds to make stable materials, in which form they are normally seen, e.g.,

calcium, essential to animal tooth and bone structure (2);

iodine, an essential constituent of important human hormones (4);

hydrogen, an essential part of water, of all organic compounds, and therefore of life itself (5).

Even such common elements as iron and cobalt do not occur freely in nature, but have to be separated from their ores. Nevertheless, they are essential to the chemical processes of life in plants and the human body, e.g., iron in the haemoglobin of our blood (8), and cobalt in vitamin B_{12} (9).

Compounds of all the above elements are fatally toxic if consumed in large enough doses, but many of them are essential to life in normal quantities. Without exception, it is the size of the dose which makes the poison, not which elements are present (21). For instance, strychnine and atropine are listed as supertoxic substances, but both are used medicinally in small doses and both contain oxygen and nitrogen, the two principal gases in the atmosphere we breathe.

In exactly the same way as these examples of other essential elements, chlorine by itself is highly reactive and corrosive, and is part of many compounds which are toxic at high dose levels; but at the same time, chlorine and its compounds are essential to human life and are present throughout our environment.

Free chlorine is produced by natural geothermal processes within the earth, and occasionally finds its way to the surface in its natural state (1). More usually, however, it reacts with water vapor on its way to the surface to form large quantities of hydrogen chloride, which dissolves in water to form hydrochloric acid. This, in turn, quickly reacts with other elements and compounds, with many of which it forms stable compounds, usually chlorides, such as sodium chloride (common salt), magnesium chloride and potassium chloride, all found in huge quantities in sea water.

Chlorine, as part of stable compounds, makes up about 0.03% of the earth's crust and nearly 2% of all ocean seawater. It exists in several minerals and, of course, as a major component of rock salt, which is the deposit resulting from the evaporation of ancient seas.

CHLORINE COMPOUNDS

When stable metal chlorides dissolve in water, the chlorine partly disassociates from its accompanying metal to form a negative chlorine ion, which can then combine easily with many other molecules, to form a large number of stable inorganic and organic chemicals. Chlorinated organic (carbon-hydrogen) compounds are often called organochlorines.

The chlorine ion in common salt water is an essential element in all animal body fluids (plasma, lymph, cellular fluids, saliva, tears, sweat, semen and milk) (11). In this form chlorine makes up about 0.15% of the total weight of the human body. Its most obvious rôle is in helping to maintain the very narrow limits of the acid-alkali balance, outside which the body's complex chemistry cannot work, e.g., in the carbon dioxide/oxygen exchange mechanism of red blood cells (12).

One of the simplest chlorine compounds, hydrochloric acid, is an aggressively corrosive and hazardous chemical, but is naturally present in the stomach of man and other mammals as a necessary part of the digestive process. This hydrochloric acid is made within the body from salt, a chlorine compound which must be ingested so that the body can survive.

A large number of complex organochlorines are naturally produced chemicals, widely present in nature, playing many essential rôles (28). They exist as thiamine, vitamin B_1 (10), and also as chloroperoxidase enzymes in the human body's defence mechanism against toxins, microorganisms, parasites, and possibly tumors (14). They also form a wide range of chemicals involved in the metabolism of bacteria, fungi, algae, plants and some higher animals (14,17). Chlorine is also an essential element in naturally occurring antibiotics such as chlortetracycline (aureomycin), chloramphenicol (chloromycetin), and griseofulvin (fulvicin) which have revolutionized the treatment of many serious human bacterial and fungal infections.

Many different organochlorines are formed in seawater as a result of a combination of natural biological and chemical processes (29), and are released into the atmosphere (15,16). Of these, chloromethane is naturally produced at annual rates variously calculated to be from 5 million metric tons (32) to 28 million metric tons (13). Natural forest and vegetation fires as well as volcanos also release chloromethane into the atmosphere (13,18,31). Carbon tetrachloride, commonly used as an industrial degreasing solvent and domestic spot remover, is universally present in the sea and atmosphere at levels which indicate a natural annual production rate of nearly two million tons (24, 27), much more than is produced by the chemical industry world wide.

Even more complex aromatic organochlorines, including dioxins and furans, are produced when wood and other vegetable matter is burned (19), as, for instance, in naturally occurring forest fires (18). These chemicals are therefore everywhere in our environment and have been so since before the existence of man. For instance, pentachlorophenol, (PCP), is present in lake bottom sediments dating back to the 17th. century, at levels very similar to the those found in modern sediments of lakes which receive paper mill effluent (23). Both dioxins and furans have been found in lake sediments dated back to 1860 (25). Our bodies have natural defences against these chemicals, so that they cause us no harm at these low levels.

The fact that inorganic chlorine compounds and organochlorines are naturally produced in such vast quantities, and are so widely distributed in the natural world, is irrefutable evidence that they are not, as is sometimes claimed, "completely alien to nature". Although, as in all human activities, artificial production must be carefully controlled so as not to destroy our environment, banning production of all chlorine compounds to keep chlorine out of the environment is clearly ineffective.

USES OF CHLORINE AND ITS COMPOUNDS

Chlorine is used worldwide to purify water supplies, and in this use alone has certainly saved millions of lives and affected each one of us. Attempts to link drinking water chlorination to cancer have not survived thorough analysis by a special working group of the International Association for Research on Cancer, and by a two year program supervised by the National Institutes of Health (20). No causal relationship was found. In a recent (1991) tragedy, poorly founded allegations that water chlorination causes cancer in humans led some water authorities to cease chlorinating water supplies in a number of Peruvian cities. The result was a cholera epidemic extending to sixteen other countries, affecting 590,000 people and causing over 5000 deaths. At a subsequent International Conference, it was forcefully stated by a World Health Organization official that the risk of microbial infection is several orders of magnitude greater than any possible risk of carcinogenicity, even if the latter exists; and that furthermore it is cruel to frighten people and cause them to abandon chlorination, thereby increasing their suffering and decreasing their life expectancy (26).

Chlorine compounds are equally important in the treatment of disease. There is hardly a class of pharmaceutical or an area of medicine in which they are not represented, often as the treatment of choice, and so have affected nearly everyone's life in the most practical way. They provide a wide range of pharmaceutical products, including medications which are antibacterial, antifungal, antiamebic, antimalarial, antidiabetic, antipsychotic, antihistamine and antitussive. They provide doctors with essential tools such as anaesthetics, antiseptics, analgesics, sedatives, vasodilators, diuretics, glucocorticoids and progestogens.

Derivatives of chlorine also include 2,4-D, a safe herbicide of low acute and chronic toxicity in animals and man which does not bioconcentrate or bioaccumulate (21); germicides which are convenient and safe in domestic use; bleaches used in commercial, hospital and domestic washing and cleaning products; solvents used in commercial dry-cleaning and domestic spot removers; and insecticides such as dieldrin and DDT, which are far more safe in use than the lead arsenicals they replaced. Dieldrin and the other chlorinated cyclodiene insecticides (aldrin, chlordane, etc.), while safer than traditional products and far more effective, proved to be too hazardous if improperly used or accidentally consumed, and most have been banned in the USA and some other countries.

After many years' experience of DDT, during which its safety for agricultural workers was proved beyond doubt (31), it was discovered that it bioconcentrates in the fatty tissues of some animals, especially fish and birds, and bioaccumulates up through the food chain, ending in man. Its use has therefore been banned in the USA since 1972, and in most advanced industrial countries. Although it bioconcentrates and is persistent in trace amounts in human fatty tissue, no ill effects have ever been firmly established at the minute levels (4 to 16 ppm) found in the general human population; indeed, these trace levels had ceased to increase by 1951, twenty years before DDT was banned (21). Few, if any, fatalities due to DDT poisoning have ever been documented in the USA, and even accidental consumption of quite large quantities has not resulted in death; nor was DDT ever found to be carcinogenic in mice or rats, and therefore, presumably, in humans (21). Many scientists, including the President of the National Academy of Sciences, maintained that the human health data used to justify the banning of DDT did not stand up to unbiased and careful scrutiny (30). In countries where fatal insect-borne diseases are common, and some risk to certain animal species can be tolerated for the sake of saving human lives, DDT is still widely used because of its efficiency and proven safety for the unskilled agricultural workers who apply it.

The largest single use of chlorine is to make PVC, a common plastic widely used in such basic building products as water pipes, window frames and electrical conduit that never corrode, and the flexible electrical insulation on wire and cable, which is a better insulator and safer in fires than the highly inflammable rubber and cotton materials it replaced.

MANUFACTURE OF CHLORINE

It has been claimed that the manufacture of chlorine and its derivatives is hazardous and produces unusually large amounts of exceptionally toxic waste products. This ignores the fact that all chemical manufacturers in the highly industrialized countries of Europe, North America and Australia operate under strict government controls, and that the people who operate the plants live near them and have the strongest vested interest in operating within, and usually well below, strict limits on workplace exposure, wastes and emissions.

In the USA, the present workplace air exposure limit for chlorine is 1.0 ppm maximum. There is action pending which may reduce this to 1.0 ppm maximum average over 15 minutes, and 0.5 ppm maximum average over an 8-hour workday (33). Similar limits are in place for chlorine derivatives; for instance, the absolute ceiling workplace air exposure for hydrogen chloride is 5.0 ppm, and 100 ppm for ethylene dichloride. There is action pending which may reduce the permitted air exposure to ethylene dichloride to 1 ppm average over an 8-hour workday and a 2 ppm absolute ceiling (33). The air exposure limit for vinyl chloride is 1 ppm averaged over an 8-hour workday, with an absolute ceiling of 5 ppm averaged over 15 minutes (34). Manufacturers are required to make measurements of actual exposure levels and to keep records available for inspection. Governments in other advanced industrial countries have similar regulations, though the details vary from country to country.

These strict workplace exposure limits are well within the levels which scientific investigations show to be safe. If these are the limits in the workplace, it is obvious that exposures to populations living nearby are several orders of magnitude less.

A recent examination of the environmental aspects of PVC production in Germany showed that actual emissions were lower than government limits (22).

None of this alters the fact that, in its elemental state, chlorine is a dangerous and highly corrosive chemical which must be treated with respect, using appropriate procedures and regulations to ensure the health and safety of all involved in its manufacture, distribution and use. Similar strictures apply to its derivatives, including such bulk chemicals as ethylene dichloride (EDC), vinyl chloride monomer (VCM) and hydrochloric acid (HCL).

SAFETY OF CHLORINE PRODUCTS

Some chlorine based chemicals, like salt and PVC, are relatively inert and inherently safe. Others, which provide health, safety and economic benefits to which we have become accustomed, are hazardous if they are used improperly. Similarly, gasoline and natural gas are also very hazardous materials, because they are explosive, inflammable and toxic, and we have a high exposure to them, even in our homes. Gasoline fires and natural gas explosions, often accompanied by fatalities, occur far more frequently than accidents with chlorine or its compounds. Nevertheless, we have learned how to control all these dangers and behave in such a way as to reduce our risk to manageable proportions. In the same way, the benefits of some chlorine based chemicals come with a responsibility to manage their use carefully and correctly so as to reduce the risk associated with them to acceptable levels.

CONCLUSIONS

It would be ridiculous to ban carbon and hydrogen simply because they are both components of dangerous materials like gasoline or natural gas, and are in highly toxic compounds like strychnine and atropine. In the same way, it would be ridiculous to ban chlorine for similar reasons.

The whole history of mankind has involved the management of natural resources to our advantage - from the use of fire, to herding animals, farming, metal extraction and refining, energy production and the manufacture of chemicals and pharmaceuticals. As our planet becomes more crowded, it becomes increasingly important to improve our understanding of vital manufacturing processes and the effect they have on the our environment, so that we can manage them appropriately.

This understanding is best developed through good science, open communications and public consensus, not by emotive public relations campaigns unsupported by scientific consensus, which only serve to confuse important issues. It may be thought that those who use these emotive tactics do so out of concern but ignorance, because of the difficulty of understanding science and technology. However, the main issues can be easily understood by reference to any good encyclopedia in a public library, without any special technical knowledge, as can be seen by many of the references in the list attached. It is disturbing that those who use emotion rather than science frequently quote well researched scientific papers, but draw conclusions out of context, often omitting the author's caveats on the lack of clear evidence or the need for more data.

Such an emotive approach may frighten uninformed people into actions which are ill-considered and may even, as we have seen in the case of water chlorination, be tragically fatal. Our goal should be the understanding and control of technology so that we maximize its benefits to society while eliminating irremediable environmental damage and minimizing temporary environmental effects.

Technology is constantly progressing, and it is certain that many chlorine based products in use today will be replaced by better and even safer materials in future. We will surely learn to improve processes using chlorine and its derivatives, so that emissions, waste products, risks and hazards will be reduced to even lower levels than those which we regard as exemplary today. It is equally certain that many of these improved products and processes will still be based on chlorine, one of the most useful of all the elements.

Peter Lloyd
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28th. October 1992.

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