

OZONE TECHNOLOGY & POLLUTION CONTROL

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INTRODUCTION

Pollution, a word known from age memorial, is a result primarily from man's interference with nature. The problem had never been acute until the last 5 centuries starting from the industrial revolution. Before this time there was a fine balance between man's contamination and nature's decontamination. The explosion in the population and the further development of industrial pollution has tipped the balance posing a serious health problem to man and animals and an environmental problem to vegetation.

a. Adverse effects of pollution

The first effect of pollution was the contamination of drinking water, contamination through improper sewage disposal and through industrial effluents. Man has finally woken up to this threat and is now attempting worldwide to restore the environment and use materials which have the least harmful effect to the environment. As the cost of pollution to health rises, the cost to incorporate antipollution methods become apparently cheaper. Governments now make it extremely costly for industries to pollute so that any process which addresses on the cost and effectiveness is always welcome.

(b) Chlorine as an anti-pollutant

Until recently Chlorine was the only product used to remove pollution, for its biocidal properties and other oxidature uses. It was the only option available. Chlorine has been shown to cause more problems than it resolved. The toxic byproducts have now been linked to cancer.

(c) Ozone as an anti-pollutant

Very recently Ozone has become the saviors to man's problems. While the characteristics of Ozone as a strong oxidant was known for several decades, its use was not incorporated as very little Research and Development was done on its use. This is because the very useful character of Ozone - its 'high reactivity' prevented research as Ozone could not be stored or bottled. Ozone generation was also expensive and only the very well to do countries (W.Germany & France) were able to carry out development in Ozone technology.

Recently however it was possible for other countries to apply Ozone in several fields as the cost of manufacture had dropped (for small scale industries). The original Ozone companies were not interested in providing their technology to small industries as they found it less rewarding. India & Australia has now pioneered in the production of Ozone generators for small scale use and developed applications specifically suited for this section - different from those used by the very large companies.

B. WHAT IS OZONE?

This question has been answered many a times .All articles on Ozone and its uses have found a brief mention on this . Even now whenever 'Ozone' is mentioned, the layman always associated this with the Ozone layer.. The International Ozone Association was formed to encourage use of Ozone. The Ozone Association of India (O3AI) was formed recently because interest in Ozone increased rapidly in the last few years. The O3AI is new in the process of making video and written presentations, to enlighten the public on Ozone Technology .

The impact of Ozone technology in industry and as antipollution agent has led to increase in research and development. The applications of Ozone in the different fields are explained briefly under respective headings.

Ozone is a triatomic oxygen gas and also known as supercharged oxygen. Upon reaction it reverts to oxygen. The reactions are very fast and in various treatment procedures its high reactivity is explained.

1. OZONE IN POTABLE WATER TREATMENT

Pollution was not a problem in the early century and Ozone application started with treatment of potable water. The cost of production of Ozone then was extremely high and only the most developed countries like France, W.Germany and much later USA, UK, Canada and other European countries were able to afford the research and development and later the use of Ozone technology in potable water treatment. The technology was reserved here too to the large government or municipal water treatment. R & D work with Ozone applications was also very limited because research institutions could not afford. As time went, more and more work on Ozone was carried out. Literature became available on the advantages of using Ozone. In one literature eg. case studies in the proceedings of International Conference (4). described excellent results of Ozone application in the city of Alberta, Canada. The bactericidal effects of Ozone on water was described and contrasted with Chlorine by Bringman (40) who observed "**that a 0.1 ppm active Chlorine needed 4 hrs to kill 6×10^4 *E. coli* cells whereas the same concentration of Ozone kills the same quantity of bacteria in 0.5 seconds**". Nebel & Nebel (3) and Fetner (43) have described the bactericidal properties of Ozone in great detail including its toxicity to other bacteria. In the 6th Ozone congress, Dr.J.Walton (2) presented a very comprehensive literature review of the relationship of Ozone and biological species. Venosa (4) has produced a literature review including technical literature references of the advantages of Ozone treatment on both water and waste water. Rip G.Rice (5) has described Ozone utilisation in Europe since 1906 .Rice is a foremost and highly expert Ozone technologist in the world. He has described the other properties of Ozone besides the bactericidal nature. Ozone remove color, iron and manganese, heavy metals, phenols, detergents cyanides, sulphites & nitrites, ammonia, etc. and makes water blue. Further importance of Ozone for drinking water

purifications is provided by Leist (6) (USA municipal water treatment), Toricelli (7) in Drinking water purification by Ozone, Stankovic (8) in Experiments with Ozone treatment of Drinking water in Yugoslavia and last but not least Ozone application in drinking water in Korea by Kang & Lee (9). The dangers of Trihalomethane (THM) as a carcinogen is accepted and the removal of its precursors by Ozone is described by Chong & Singer (10). They also explain the reduction of TOC (Total Organic Content) by Ozone. The danger of Chlorine has been made aware even on India in an article in Life line. (Weekly Indian Express feature Aug 21, 1993 (12) and the advantages of Ozone mentioned at the SPTCA meeting at California (11). The toxicological effects of Chlorine is referred to L.W.Candie-abstract enclosed and improvement of taste (41).

One of the pioneers in Ozone Technology - Trailigaz of France (now ITT WEDECO) has given via Leist (6) a review of operating experiences of Ozone systems in Municipal Water Plants in USA. Leist has included case studies of potable water applications on Daytona Beach Florida, Belleglade also of Florida and Springfield, Minesotta. He has outlined various problems encountered and the solutions to the problems providing a wealth of experience to Ozone specialists throughout the world.

2. OZONE IN INDUSTRIAL EFFLUENT & WASTEWATER TREATMENT

The use of Ozone for effluent and wastewater treatment is yet to mature. More and more applications of Ozone in this field are being developed as cost of manufacture of Ozone reduces relative to the high cost of pollution. Only a very short review of applications is provided in this article so as to stimulate the interest in India. A case history of Ozone application in Wastewater Treatment in the city of Quebec has been described at the Proceedings of the Second International Conference at Edmunton, Canada (13). Ozone has been used to treat wastewater from diary products, rubber and tile manufacturing electroplating, aluminium extension and other contaminants. Other applications include the

bleaching of pulp in substitutes for Chlorine which produced very toxic by product effluent. This is described in the section on other applications.

The kinetics of Ozone reaction in wastewater system have been described by Farrok & Ahmeed (15) which shows the highly scientific and accurate culture of Ozone application & utilization.

3. OZONE IN MEDICAL THERAPY

Application of Ozone on medicine is a relatively new concept. This concept evolved from the fact hyperbaric oxygen has been found to be extremely useful in skin burns and skin restoration. The oxygen helped reduce scarring and hastened healing. Ozone has a double effect of killing bacteria as well as providing oxygen which is used in cutaneous respiration, suppression of bacteria growth as well as hastened recovery. Interest in the reactions of Ozone with biological fluids and systems were around the West Germany where formal applications for permission to use Ozone in medical therapy were made and granted. Prof. Dr. Med S Rilling (16) of Stuttgart Germany has carried out with his associates many tests in Ozone with biological systems and has described briefly in a brochure attached and in an article.

While Ozone application as a gas within the human body is still classified as a very high specialised application and require proper training, external applications of Ozone on other diseases were certainly useful to try. Ozone has been found to be particularly useful in treatment of diabetes ulcers persistent viral dermatitis, fungal infections antibiotic resistant staphylococcal infections and gangrene. Ozone has been used as insufflation for intestinal disorders, piles etc. With the availability of a cheaper Ozone generator, Ozone applications in other factors of medicine can be tried. There is a tremendous scope of research in this field and attempts will be made to proceed in India. Ozonated water can used as oral or dental wash in oral surgery which reduces the trauma of the patient, reduces bleeding and infections. Application of Ozone in Aids treatment is being carried out in various research

centres in USA as a communication to Dr.Lave from Medizone International (17). IOA has now established a medical section for the information of members of advances on the medical field.

Ozone can be used in sterilising surgical equipment and particularly where methods are not either practical or reliable. This applies to Dental tools which according to a study (46) has found that they may carry HIV virus.

4. OZONE IN COOLING WATER TREATMENT

Applications of Ozone on cooling water treatment was purely incidental. The toxicity of Chlorine and other bichlorides and the conceivness of Chlorine led maintenance chemists to look for other methods of cooling water treatment. The application of Ozone on cooling towns were tested out in an experimental basis by IBM (38), NASA (44) at Kennedy Space Centre.

Advantages of using Ozone in cooling tower water.

The advantage of Ozone in cooling water treatment were expressed viz.

- (a) Ozone is a very effective biocide and maintains the cooling water systems at very low level of bacteria.
- (b) Ozone has no side effects in that the final product of reaction is Oxygen & CO₂ unlike Chlorine and other biocides which pollute the storm water systems.
- (c) Ozone has been found to remove scale and prevent formation of scale so that the systems remain efficient and there is no frequent breakdown and is easier for maintenance.
- (d) Ozone has the tendency to reduce corrosion if applied properly.
- (e) The cooling towers can be operated at higher levels of TDS so that water consumption is reduced.

These information is given in a summary report (18). A feature report of Ozone practical of cooling tower water is also enclosed (19). Dr.Wild (20) presented at a conference of IPEA of application of Ozone under 'An Environmentally Safe Method for the Control of Microorganisms in Cooling Towers'. The relative cost of Ozone treatment in cooling tower have also been discussed (21). In many of these cost appraisals the social cost, labor saving cost etc are immeasurable. Legionella infection has been arrested with the use of Ozone to cooling water towers.

5. SWIMMING POOL & SPA WATER TREATMENT

Ozone treatment for swimming pool & Spa had never been considered of great importance. However, the harmful effects of chlorination had led water treatment specialists in the developed countries to consider an alternative to Chlorine. The advantages of Ozonation include a very sparkling polished blue pool water, free of organics and bacteria. This meant swimmers need no longer worry about eye irritation, Chlorine smell of hair, bleached swim wear etc. The other danger of toxic chloramines which cause all this side effects and being known as carcinogens are eliminated by Ozonation.

Ozonation Accepted as standard treatment for Olympic Games Pools

Ozonation has now been accepted as the treatment for all the swimming pools for the olympic events. This started at the LA Games (26) and continued in all other subsequent venues.

The article - 'An Ozone primer' the swimming pool and spa Merchandise May 1984 describes. The experience an Ozone treated pool (27). Rip Rice, a world authority on Ozone has been presented in the 1985. NSPI Aquatic Symposium in Houston April 2 viz. The Effect of Ozone on swimming pool water treatment and the reduced need for Chlorine. This is repeated in pool & Spa News May 26 (29).

Chlorination apparently is insufficient to stop Pseudomonas infection in Spas. This is because Chlorine evaporates rapidly in the warm water and the residual Chlorine is not strong a bactericide. Ozone on the other hand is so potent a bactericide that the small concentration in the warm water is sufficient to eliminate Washburn *et al.* reports this in the JAMA (28).

Another incident of a similar infection has been noted in a water slide in also reported in JAMA on Medical News (50).

Several case reports have been described in the article by HD Rose *et al.* in the same journal (49). This only shows that Ozone is a preferred alternative even if the equipment cost is high. Jacobson *et al.* (50) reports pool associated skin rash in 1976. Urinary tract infections of the same class of bacteria have been associated in Chlorinated swimming pools which can be improved by Ozone. Pacik & Rice (29) reveal a new process of Ozone treatment of pool with a residual chemical combination. Jacoby has given in another clear article the advantages of Ozone treatment for swimming pools & Spas (30).

6. ANTI POLLUTION APPLICATIONS OF OZONE

With the laws on pollution being strengthened every day, the social and financial cost of pollution is becoming very much higher. It is imperative to seek cheaper methods of pollution control and Ozone has become a very convenient and cheaper method to control pollution.

Ozone use in Sewage & Effluent pollution

This common pollution has been treated with chemicals and Chlorine. The resultant outflow resolved the problem but produced other problems. The cost of treatment by conventional methods was high and second the efficiency of treatment for that cost was low.

With increasing Health Standards of air and water, chemicals alone are unable to fulfil the requirements.

Ozone has been tested to combat these protections and was able to eliminate the pollutants successfully. Certainly the cost of Ozone generators again limited the application but with the manufacture of cheaper equipment in India we can now start to tackle these problems. More details are given under waste water treatment.

7. OTHER INDUSTRIAL USES OF OZONE

Mariculture and Aquarium

Living organisms be it terrestrial or aquatic produce waste and in the case of aquatic organisms they succumb to their own toxic waste if they are not removed. Removal of the toxic waste may require chemicals which in turn have to be removed failing which they become toxic. The existing procedures therefore are cumbersome tedious and expensive. Ozone, being very highly active is suitable to remove the toxic waste. The advantage of the Ozone is that the side product oxygen is a desired and beneficial to aquatic animals.

The Japanese being specialists in seafood have their main industry in this field and have quickly adapted Ozone as a means to remove nitrogenous waste particularly Ammonia. Reactions of Ozone are different in sea water and fresh water. A study on ozonation of sea water and maintenance of fish under the appropriate conditions has been described by Kobayoshi *et al* (32) Sweswarda describes the use of Ozone in aquarium (33) and in the paper pulp industry (39,14).

There are several other applications in the scientific industry where Ozone has proved to be very useful. Many other applications are feasible but not tried purely for want of equipment at reasonable cost and technical expertise.

8. OZONE IN PRESERVATION INDUSTRY

Ozone while acting as a biocide also helps in preservation of food and vegetables. Vegetables remain fresh longer in the presence of Oxygen side product with no bacteria or fungus to destroy them. In the transportation of prawn harvest, Ozonation prevents rapid bacteria infestation which cause the prawn catch slime and smell. Likewise contamination of Salmonella and coliform mushroom and freshly killed chickens are removed by Ozone. Chickens are currently sterilized by strong Chlorine solutions which give toxic chloramines as a by product.

9. ATMOSPHERIC POLLUTION

Ozone has the ability to remove odor as well as smell and color - Dicknson (42). Ozone reacts with organic particles and chromogens which produce the smell and color break than down by oxidation and the clean the air. A Morr (31) describes an installation clearly thus which resolved this problem (Hydrogen Sulfide) using Ozone. Toxic gases such as (O, methane, etc. are oxidised by Ozone. Ozone can be applied to effluent gases from industries so as to maintain a cleaner environment.

10. CONCLUSIONS

Ozone technology can be considered as another technological revolution like aviation, electronics, computers etc. The applications of Ozone like in electronics are infinite. More and more applications are being discovered and Ozone research is indeed a topic to be encouraged. Also in many countries, the concerned governments have granted special status to encourage the use of Ozone in as many field as possible since this will in

due cause reduce the cost of medical treatment or antipollution treatment, increase pollution control and in general improve the health of the population (and reduce the medical costs).

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