# ACHIEVING REQUIRED RESIDUAL OZONE IMPORTANCE IN PHRAMA WATER TREATMENT

By V.Baratharaj

**OZONATION IS MORE THAN JUST INTRODUCING OZONE IN THE WATER. FOR OZONATION TO BE EFFECTIVE IT IS VERY IMPORTANT TO ACHIEVE THE REQUIRED RESIDUAL OZONE AND MAINTAIN THE SAME DURING CONTACT TIME DESIGNED. KINECTICS OF OZONE DETERMINE IS MOST OFTEN OVERLOOKED DURING DESIGN**

Pharmaceutical Industry have very rigid process controls and evaluation. In water treatment determination of Bacteriological standard requirement takes time. Accelerated tests are not allowed. Tests results are know after days . Hence the requirement should be to adopt a system that can measure standards on line and ensure that each time the water passes tests requirement

Ozone has become a preferred disinfectant due to the following reasons:

1) Ozone is eco- friendly and does not leave behind ant toxic residues unlike chlorine and its compounds
2) Ozone resistance to bacteria is not common
3) Ozone actions and results are very predictable
4) Ozone contacting requirement are short unlike chlorine
5) Ozone results are measurable on line and 100% of the time the results meet required standards

Ozone is a very unstable gas and needs to be used immediately when it is formed. Also the half live in water is just 20 minutes and that too dependent on other kinetics. Getting to this ozone residual and maintain this residual throughout the contacting time is a challenge

Difference between achieving residual ozone in packaged water and achieving the same in phrama waters is that in packaged water you have the ozone as a preventive treatment whereas in phrama waters it is actual treatment . Hence system design is slightly different..

Ozone use in Phrama Process water : ozone is mostly used for removal of resistant pathogens especially gram negative strains .In the process other pathogens such as coli forms , staphylococcus and streptococcus strains are also removed . Ozone has broad spectrum of actions on pathogens with a kill rate almost 100% . ozone properties of decolonization , heavy metal precipitations are helpful when ozone is used in pretreatment .

Ozone has its disadvantages also. It is short acting, Actions and subsequent efficacy are design based and ozone leaks can be toxic to operators.

**Consideration of ozone kinetics**

In majority of cases, the Ozone is just introduced into the water from the Ozonator into the Treated water tank. ( Diffusion method) .Ozone users often complain that they are not achieving required residual ozone levels .A combination of inadequate ozone production , insufficient ozone dose & low ozone concentrations & wrong mixing technology could likely be the root cause for the following :

Studies have revealed that Introducing ozone into a tank does not provide sufficient ozone mixing . Stable ozone residuals are never achieved by these methods because the incoming water flow and the applied ozone feed gas are usually spread across the entire cross sectional area of the tank ,weakening the available energy input for two phase mixing. Such methods do not prevent channeling of gas bubbles and provide adequate gas liquid contact

**DANGERS OF INCOMPLETE OZONE REACTIONS DUE TO LOW MASS TRANSFER**

Natural waters contain varying quantities of humic and fulvic materials ( organic compounds) . These are low molecular weight substances that can be degraded to simpler non polymeric oxidation products. These are all readily bio-degradable products that represent food for the micro organisms. Therefore if the ozonation is not allowed to complete , to further oxidize these compounds, than there is an increased risk of micro-organism growth by producing assimilable food. Thus care to be taken that all the reactions are complete and organic oxidized.

Obtaining Residual Ozone, is the combination of various parameters that affect the kinetics of Ozone. The following factors play a very important part.

1. The dosage and concentration of Ozone.
2. The temperature of the water
3. The methodology of ozone dissipation
4. The pH of the water
5. The type of pre-treatment and the subsequent contact time for ozonation.

1. **THE DOSAGE AND CONCENTRATION OF OZONE.**
   The ozone being a sparingly water, its dissolution in water is governed by Henry's law. The higher the concentration of the ozone the more it dissolves. By using a higher concentration a high ozone residual can be achieved. . Oxygen concentrators are deployed to increase the concentration. Ozone concentrations need to be around 6-8% for effective results

## 2. THE TEMPERATURE OF THE WATER

This plays a very crucial role. The lower the temperature the more the Ozone will dissolve. The following table will make this point very clear.

| | Water Temperature. Degrees Celsius | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0 | 5 | 10 | 15 | 20 | 25 | 30 |
| OZONE ($O_3$) in Air | OZONE ($O_3$) in Water | | | | | | |
| 1% by wt (=12.07 g/$m^3$; = 6,044 Ppm-vol.) | 8.31 | 7.39 | 6.50 | 5.60 | 4.29 | 3.53 | 2.70 |
| 1.5 % by wt (= 18.11 g/$m^3$; = 9,069 ppm-vol.) | 12.47 | 11.09 | 9.75 | 8.40 | 6.43 | 5.29 | 4.04 |
| 2% by wt (=24.14 g/$m^3$; =12,088 ppm-vol.) | 16.62 | 14.79 | 13.00 | 11.19 | 8.57 | 7.05 | **5.39** |
| 3% by wt (= 36.21 g/$m^3$; = 18.132 ppm-vol.) | 24.92 | 22.18 | 19.50 | 16.79 | 12.86 | 10.58 | 8.09 |

***Note:*** ***The concentration of Ozone gas is determined at a standard temperature of 20 Degrees. Cel. (68 Degrees. F) and a standard pressure of I atmosphere (101 kPa).***
**COURTESY** 34th Annual Meeting of Society of Soft Drink Technologists, Las Vegas, APR1997

From this table it could be understood the higher the concentration, the higher would be the ozone dissolution, allowing us to achieve a higher ozone residual. The normal temperature of water will be around 30-35 degrees which means that the amount of ozone that dissolves will be little . It must be noted that all the ozone that is dissolved in the water does not go to produce the ozone residual . ozone is fast consumed by organics and other compounds and only after the water is devoid of ozone consuming compounds will the residual ozone be obtained.

## 3. THE TYPE OF OZONE DISSIPATION DEPLOYED

Ozone Can be introduced into the water by three methods
a. ventury b. diffusers c. Static Mixing

The venturi mode is a flash mixing that can guarantee 99% transfer of ozone into the water . For Phrama process water ozonation normally this type is preferred. This process is often termed as side stream method. The selection of the venturi will play a very important part. It is the dissolved Ozone that will respond to the residual tests and likely to remain in the water for a longer time.

Diffusion methods are deployed for higher grade ozone applications and can be either dome type or radial type.

**How do you select the venturi and the pump.**

Locally fabricated venturis must be avoided . There are highly specialized companies across the world that manufacturers good quality venturi that is supported by a performance data and curve . Each venturi has a suction capacity based on the inlet and outlet pressure and flow of water across the venturi

Similarly pumps have performance data and curves . The ozonator produces ozone mixed with oxygen at a flow and pressure equal to the feed gas flow.

This is used to define the suction required from the venturi and the flow and pressure against this suction is fixed and the pump selected based on this requirement. This will ensure that 99% of the ozone .oxygen flow is sucked into the venturi

**Other Mass transfer devices :**

Introduction of mass transfer devices like mass multiplier nozzles, satic mixers will help in ozone mixing . Static mixers are placed inside pipes wheras the nozzles are placed inside the contact tanks

## 4. THE pH OF THE WATER

Ozone dissociates into hydroxyl group at higher pH. Therefore if the pH of your water is around 8.0 and above you can be rest assured that some of the Ozone will covert itself to hydroxyl group that will effect the residual ozone level. Hydroxyl group are poor disinfectants though they are powerful oxidizing agents

## 5. PRE-TREATMENT AND THE SUBSEQUENT CONTACT TIME FOR OZONATION

Whenever chlorine is used as a primary disinfectant the little residual chlorine that will always be present even after SMBS will effect the residual ozone, Small amounts of chlorine, (as low as 0.05 PPM) is normally present even after SMBS stage This will effect the residual ozone measurement. One way of avoiding this during measurement is to use malonic acid reagent while measuring ozone in the lab. The online dissolved ozone measurement will also show lower ozone residual than actual

The contact time is important for two reasons : 1) to ensure you achieve the ozone residual 2) to ensure you achieve the required CT factor of the pathogens . Both must be achieved .Achieving ozone residual and not maintaining the contact time will allow bacteria to re-grow after the ozone

residual decreases or ozone disappear from the water . The bacteria has to be fully destroyed to ensure no growth result after bacteriological testing. The ozone system should therefore control this part of the process so that subsequently you can depend on online ozone measurements to predict the quality of the water

## OZONE RESIDUAL , E.COLI DESTRUCTION & MICROBIAL GROTH.

The final sanitation level in water is often judged by the presence of E.Coli ( most difficult pathogen to kill ) and the microbial growth ( Total plate count after 48 hours.) . Maintaining a residual ozone of just 0.03 ppm with a contact time of just 1 sec. can almost result in a 99% destruction of E-coli . A 0.02 ppm residual ozone can achieve a NO MICROBIAL GROWTH result. However in practice systems that are designed for a residual ozone of 0.2-0.3 ppm and a contact time of above 12 minutes will provide more confidence in Pharmaceutical industries because of the requirement of rid gram negative bacteria such as pseudomonas strains that are tough to kill .

V.Baratharaj ,is a qualified Phramacist and has nearly 25 years experience in Ozone and is the Chairman and Managing Director of Ozone Technologies and Systems India Pvt Limited , a leading Chennai based Company specializing in ozone applications .He can be contacted at otsilozone@gmail.com