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Oxidation vs. Ozonation in Drinking Water Treatment: A Comparative Analysis

Dr. Parag Dalal

Asst. Prof. School of Studies in Environment Management, Samrat Vikramaditya University Ujjain

Abstract
Every year, millions of people get sick from water that isn't clean. Making sure our drinking water is safe isn't just nice; it's a huge task, especially with new threats popping up all the time. Imagine tiny, harmful bugs, chemical spills, or even just weird tastes and smells in your tap water. These problems make it tough to deliver truly clean water to homes and businesses.

Thankfully, smart solutions exist. Oxidation and ozonation are two big players in advanced water treatment. They both help make water pure, but they work in different ways. Understanding these methods shows us how we fight invisible dangers to keep our water safe to drink.

Understanding Oxidation in Water Treatment

What is Oxidation?

Think of oxidation like a chemical cleaning process. It's when a substance loses electrons, changing its makeup. In water treatment, this process targets bad stuff in the water. Oxidizing agents basically attack these unwanted parts, breaking them down or changing them so they aren't harmful anymore. It's a key step to get rid of things that cause trouble, like ugly colors or dangerous germs.

Common Oxidizing Agents

Many different chemicals can act as oxidants in water. Each has its own strengths and how it affects the water. Let's look at some common ones.

Chlorine (Cl_2)

Chlorine is a superstar in water treatment, used widely for decades. It's great at killing off most bacteria and viruses, making water safe from many common illnesses. Plus, it leaves a little bit behind in the pipes. This "residual" chlorine protects your water all the way to your tap. But, it can sometimes react with organic matter in water to form unwanted by-products, like trihalomethanes (THMs).

Chlorine Dioxide (ClO_2)

This chemical is a step up from chlorine in some ways. Chlorine dioxide is a stronger oxidant, especially good at tackling certain tough microbes and those pesky taste and odor issues. It's also known for making fewer of the halogenated by-products that chlorine creates. This can be a real plus for water quality.

Potassium Permanganate ($KMnO_4$)

Potassium permanganate helps mostly with iron, manganese, and certain taste and odor problems. It's effective at making these metals settle out of the water. One thing to watch out for, though, is that it can create a fine, dark sludge of manganese dioxide. This needs to be filtered out later.

Ozone (O_3) - A Powerful Player

Now, let's talk about ozone. While it's an oxidant like the others, ozone stands apart. It's one of the strongest oxidants used in water treatment. Thinking about its power gives us a good lead-in to how it works. Ozone brings a whole new level of cleaning to the table, and it's making waves in the industry.

The Power of Ozonation

The Science Behind Ozonation

Ozone (O_3) isn't something you buy in a bottle. It's made right where it's used. Large machines create ozone gas on-site, either by sending electricity through air (corona discharge) or by using ultraviolet (UV) light. Once in the water, ozone starts working fast. It attacks impurities in two main ways: directly, by reacting with certain molecules, or indirectly, by forming super-reactive "radicals" that demolish contaminants. This dual action gives ozone a huge advantage. Its ability to oxidize is far greater than many other common treatments, making it incredibly effective.

Applications and Benefits of Ozonation

Ozonation offers many big wins for water quality. Its strength means it can tackle problems other treatments struggle with.

Microbial Inactivation

Ozone is like a superhero against germs. It knocks out a wide range of harmful microbes, including tough bacteria and viruses. What's more, it's especially good at destroying protozoa like *Giardia* and *Cryptosporidium*. These tiny bugs are known for resisting standard chlorine treatments, but ozone handles them with ease. It truly boosts safety from disease-causing organisms.

Taste and Odor Control

Ever had water that just tasted...off? Ozone is excellent at fixing that. It breaks down the organic compounds that cause those funky smells and bad tastes. Things like geosmin and MIB, which give water an earthy or musty smell, don't stand a chance against ozone. Your water becomes much more pleasant to drink.

Removal of Contaminants

Beyond germs and smells, ozone tackles a host of other unwanted substances. It can remove many different organic chemicals, from pesticides and medicines to industrial pollutants. If your water has iron or manganese, ozone will oxidize them, making them easier to remove. This broad effectiveness makes it a versatile tool for complex water problems.

Disinfection By-product (DBP) Considerations

One of ozone's biggest strengths is how it handles disinfection by-products. Unlike chlorine, which can form regulated halogenated DBPs, ozone usually creates far fewer of these. This means cleaner water with less risk from these specific compounds. However, it's not perfect; under certain conditions, ozone can react with bromide ions in water to form bromate, which needs careful monitoring.

Oxidation vs. Ozonation: A Direct Comparison

When choosing how to treat water, understanding the key differences between general oxidation and ozonation is crucial. They each have their own strengths and weaknesses.

Efficacy Against Microorganisms

How fast and well does each method kill germs? Ozone is generally much quicker and more powerful than chlorine or chlorine dioxide. It can achieve high levels of microbial inactivation, often measured in "log reductions," in very short contact times. For example, some studies show ozone can reduce specific pathogens by 3 to 5 log units (meaning 99.9% to 99.999% removal) faster than chlorine. This speed is a huge advantage for safety.

- **Microbial Inactivation Rates:** Ozone works super fast against most waterborne pathogens. It inactivates bacteria, viruses, and even tough protozoa much quicker than chlorine.
- **Resistance to Treatment:** Remember *Cryptosporidium*? It laughs at normal chlorine levels. But ozone destroys it effectively. This makes ozone a go-to for raw water that might have these resistant invaders.

By-product Formation

What unwanted chemicals are left behind? This is a big part of the comparison.

- **Halogenated DBPs:** Chlorine can create things like THMs and haloacetic acids (HAAs). These are regulated because they might pose health risks over time. Ozone, on the other hand, makes very few of these. This is a major benefit for reducing long-term health concerns.
- **Ozone-Specific By-products:** While ozone largely avoids halogenated DBPs, it does have its own specific by-product concern: bromate (BrO_3^-). If the raw water has bromide ions, ozone can turn them into bromate, which is a possible carcinogen. Water plants using ozone must strictly control this. Other organic by-products can also form, but these are often less harmful.

Operational Considerations and Costs

It's not just about how well they clean; it's also about how much they cost and how hard they are to run.

- **Capital Costs:** Setting up an ozonation system costs more upfront. You need special equipment to make the ozone gas. Chlorine systems, while still an investment, are generally less expensive to build initially.
- **Operating Costs:** Ozone systems use a lot of electricity to generate the ozone. Chlorine systems, however, have ongoing chemical costs for buying and storing chlorine. Maintenance for ozone equipment can also be more specialized.
- **Complexity:** Running an ozone system needs more technical know-how. Operators need special training to manage the equipment and monitor for things like bromate. Chlorine systems are usually simpler to operate day-to-day.

Residual Disinfection

What keeps the water clean after it leaves the plant? This is a critical point.

- **Chlorine's Advantage:** Chlorine is fantastic because it stays in the water. It provides a "residual" that travels through the miles of pipes in the distribution system. This residual keeps fighting any new germs that might get into the water before it reaches your tap.
- **Ozone's Limitation:** Ozone has a very short life. Once it's done its job in the treatment plant, it quickly breaks down. It doesn't leave a protective residual in the pipes. This means water treated with ozone usually needs a second disinfectant, often chlorine or chloramines, added before it goes out to homes. This "secondary disinfection" ensures lasting safety.

Real-World Applications and Case Studies

Seeing these methods in action helps us grasp their real impact. Many communities have made big changes to their water treatment.

Case Study 1: City X Switches to Ozonation for Taste/Odor Control

The people of City X were always complaining about their water. It had an earthy, musty taste and smell, especially during certain seasons. Their old chlorine treatment just couldn't fix it. The city decided to try ozonation. After installing the ozone generators, the results were amazing. Customer complaints about taste and odor dropped by over 90%. Residents finally had clean-tasting water they enjoyed. This showed how ozone could solve a major quality-of-life issue for a community.

Case Study 2: Enhanced Disinfection with Ozone at a Municipal Plant

A large municipal plant faced a tough challenge: their raw water source sometimes had high levels of *Cryptosporidium*. Their current disinfection wasn't enough to guarantee safety. They added ozone as a primary disinfectant early in their treatment process. This move significantly boosted their microbial inactivation. Data showed a consistent 99.9% reduction of *Cryptosporidium*, giving residents much safer drinking water. This change helped the plant meet strict new water quality rules and protect public health.

Expert Insights and Future Trends

What do the pros think about these methods? And where are we headed next in water treatment?

"Ozone's ability to tackle resistant pathogens and complex organic compounds is unmatched by traditional chlorination alone," explains a leading water engineer. "It gives us a powerful first line of defense, but we must also carefully manage bromate formation." This highlights ozone's strength and its unique challenge.

Another utility manager notes, "While the upfront cost of ozone is higher, the long-term benefits of reduced DBP formation and superior water quality often outweigh that initial investment, especially as regulations get tougher." This points to the strategic thinking behind choosing advanced systems.

Ozone and Advanced Oxidation Processes (AOPs)

Water treatment is always getting better. A big trend is combining ozone with other methods, like hydrogen peroxide or UV light. These combinations create "Advanced Oxidation Processes" (AOPs). AOPs produce even more powerful oxidizing agents, making them super effective against very stubborn contaminants that ozone alone might miss. They represent the cutting edge in contaminant removal.

Optimizing Disinfection By-product Control

Finding the perfect balance is key. Researchers are constantly looking for new ways to lower DBP formation from all types of oxidation. This includes better ways to remove precursors (the stuff that reacts to form DBPs) before disinfection. The goal is to maximize germ killing while minimizing any harmful side effects.

Integration and Hybrid Systems

No single solution is perfect for every water source. The future of water treatment often involves "hybrid systems." This means combining different processes, like using ozone for primary disinfection, followed by biofiltration, and then chlorine for residual protection. This multi-barrier approach gives the best overall water quality and protection.

Results and Discussion:-

In Ujjain, We set up the sites for the analysis of drinking water. The samples can be taken from the different 7 different areas in the different conditions. They are

- Collrctorate – Kothi Palace Ujjain

- Damdama – Jila Panchayat Ujjain
- Samrat Vikramaditya University Ujjain campus
- Mahananda Nagar Ujjain
- Ujjain Engineering Collage Campus, Ujjain
- Police Line campus Ujjain
- Mahashweta Nagar Ujjain

We work on 25 Parameters in Oxidation and different types of methods in Ozoneation and found the difference in the process. The comparision between the process is shown in the table below.

Table 1:- Comparison between process of Oxidation and Ozoneation in purification of drinking water

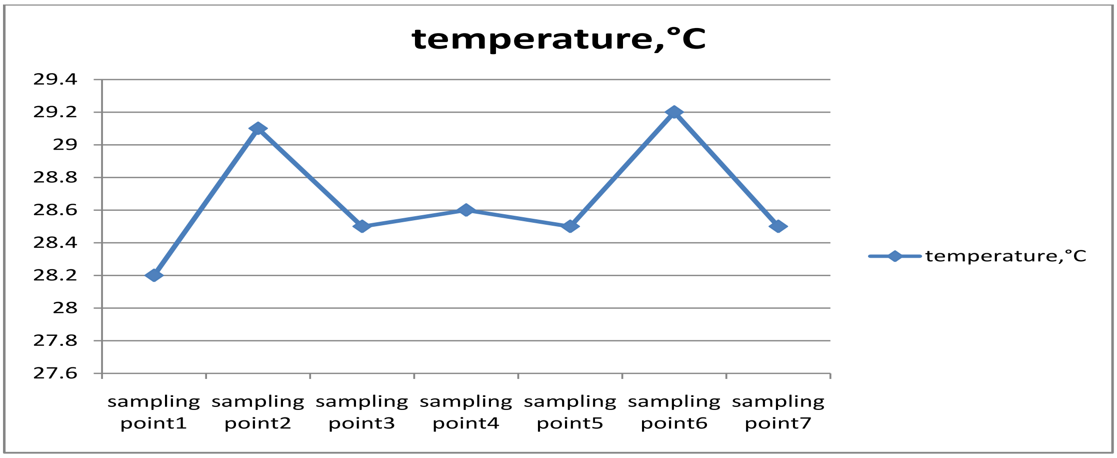
OXIDATION										**OZONEATION**	
S. NO.	**PARAMETER**	**UNITS**	**RESULTS**							**METHODS**	**RESULTS**
			1	2	3	4	5	6	7		
1	TEMPERATURE	0°C	28.2	29.1	28.5	28.6	28.5	29.2	28.5	IR Thermometer	25.6
2	COLOUR	Pt-Co Scale	1	1	1	1	1	1	1	Calorimetric	3
3	ODOR	-	Odorless	-	-	-	-	-	-	Orgenoleptic	Odorless
4	Turbidity	NTU	8	6	5	4	3	3	4	AAS	1
5	pH	pH Units	8.50	7.93	8.11	8.11	7.92	7.93	7.98	Electrometric	7.30
6	Spec. Cond.		1047	1416	1250	1292	943	950	960		800
7	TS	mg/l	750	912	885	820	851	836	830	Gravimetric	50
8	TDS	mg/l	722	882	812	765	814	810	875	Gravimetric	43
9	SS	mg/l	23	30	50	54	36	35	55	Gravimetric	40
10	AMMONIUM NITROGEN	mg/l	0.048	.0192	1.2018	0.975	1.3298	1.3114	1.5	Calorimetric	0.05
11	NITRITE NITROGEN	mg/l	0.0150	0.006	.0196	0.30	0.138	0.012	1.03	Calorimetric	0.40
12	NITRATE NITROGEN	mg/l	0.64	3.92	4.56	5.5	3.85	3.24	3.01	Calorimetric	0.21

13	PHOSPHATE	mg/l	.23	.062	.106	.087	.075	.095	1.2	AAS	0.25
14	CHLORIDE	mg/l	157	220	225	226	241	235	235	AAS	5
15	TOTAL ALKALINITY	mg/l	330	235	270	233.2	375	225.5	220	Digital Titrater	180
16	TOTAL HARDNESS	mg/l	348	350	358	332.2	219	253	222.3	AAS	30
17	CALCIUM HARDNESS	mg/l	138	75	65.5	77.5	107.2	107.1	86.5	AAS	16
18	MAGNESIUM HARDNESS	mg/l	210	169	192	155.4	111.5	146.2	136.2	AAS	11
19	SULPHATES	mg/l	70.5	84	91.5	96	90.75	93	34.75	AAS	21
20	BOD	mg/l	10	13	12	12	13	15	15	Dilution	10
21	COD	mg/l	58	65	70	70	75	74	68	Dilution	25
22	DO	mg/l	6.2	6.7	7	7.2	6.6	6.5	7.4	BOD	8
23	SODIUM	mg/l	95	128	135	124	128	135	127	AAS	15
24	POTASSIUM	mg/l	19	20	20	20	21	20	78	AAS	15
25	COLIFORMS	MPN/100 ml	>=1600	>=1600	>=1600	>=1600	>=1600	>=1600	>=1600	Filtration	nil

Discussion: -

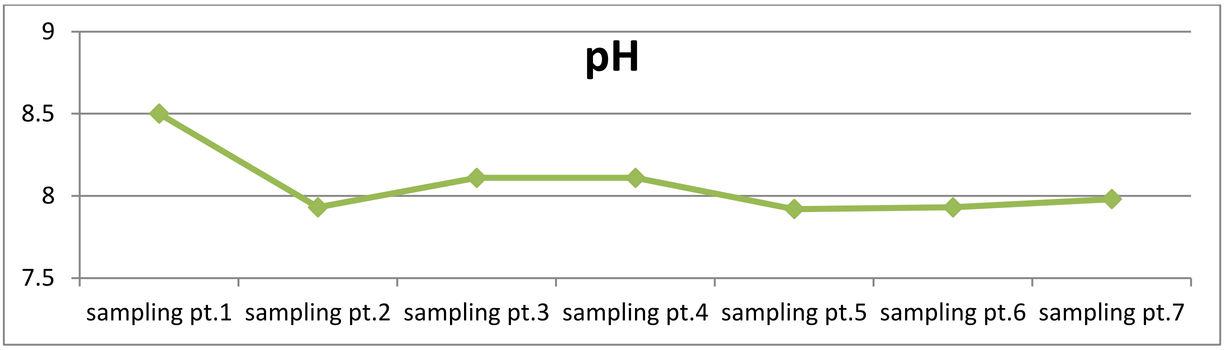
We took parameters for purification of drinking water such as Odor, Color, pH, COD, BOD, Taste, Turbidity, Aluminum, Copper, Zinc etc. and different methods. For color, order and pH are taken in Pt - Co scale and for Turbidity it has a unit of Nephelometry Turbidity Unit (NTU). For all other parameters we have single unit of mg/l.

Turbidity & Temperature: - For the Turbidity, it depict its reduction in drinking water is high unlike we want, which we found between 3 to 8 with Oxidation. We can see in the graph, the square dots represents the Turbidity having unit of NTU and with Ozoneation the turbidity is relatively close to one of every sample taken, which is considered healthy water to drink. Temperature should be maintain nearer to 25°C for the normal drinking water and this depicts both the Oxidation and Ozoneation processes, but the Ozoneation process looks more close to the this parameter.



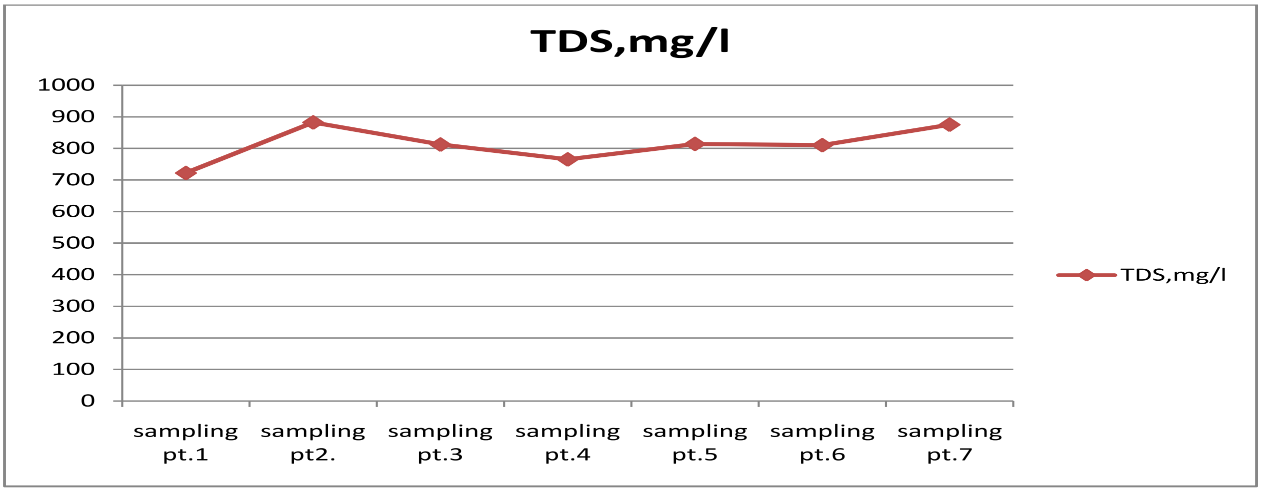
Graph – 01 – Temperature

PH: - For pH when we see the graph it shows the different reading of the Oxidation process. In Oxidation process the we found that the drinking water has the pH around 7.90 while in the Ozoneation process we perform Electrometric process by which the result can be around 7.30 pH.



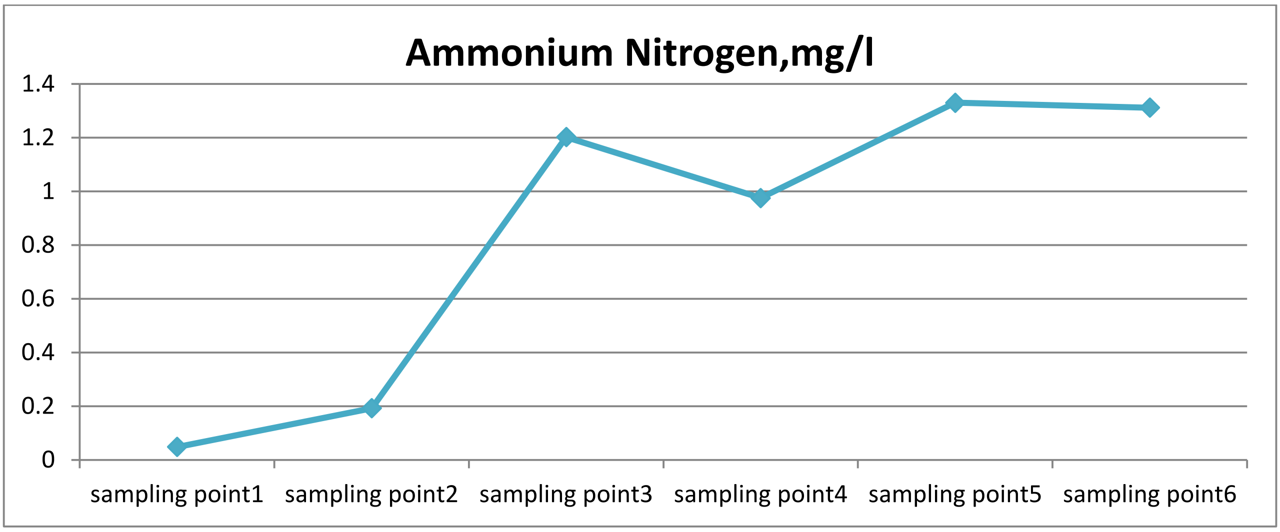
Graph – 02 – pH

Total Dissolved Solids: - About total dissolved solid (TDS), it depicts above it (oxidation) is decreased as the drinking water having sulfates and it can forms salts with Na, K, Mg etc. so TDS is high and from Ozoneation by Gravimetric process these pollutants and impurities are reduced, which lower the TDS of every seven taken samples that is close to 430 mg/l that can be assume better for drinking water.



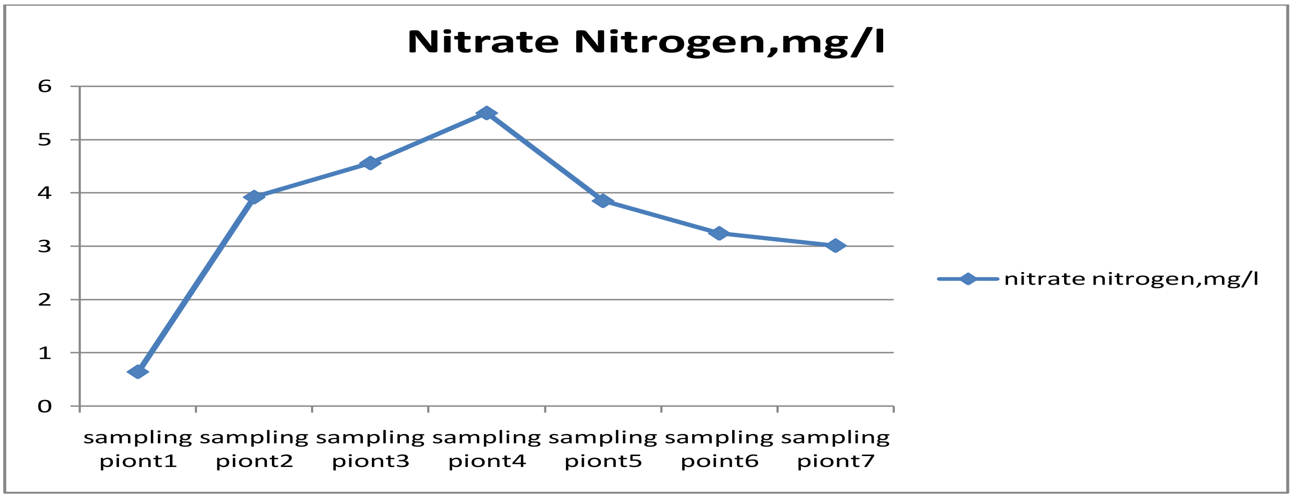
Graph – 03 – Total Dissolved Solids

Ammonium Nitrogen:-The USEP has not established a Maximum Contaminant Limit (MCL) for ammonium in drinking water that is 0.25 to 0.32 mg/l. Oxidation reduced as the drinking water had Fecal pollution, So Ammonium Nitrogen is high (<.32) and from Ozoneation by Colorimetric method the pollutants from water are eliminated up to 0.31mg/l of every taken sample and that is good considered to drink.



Graph – 04 – Ammonium Nitrogen

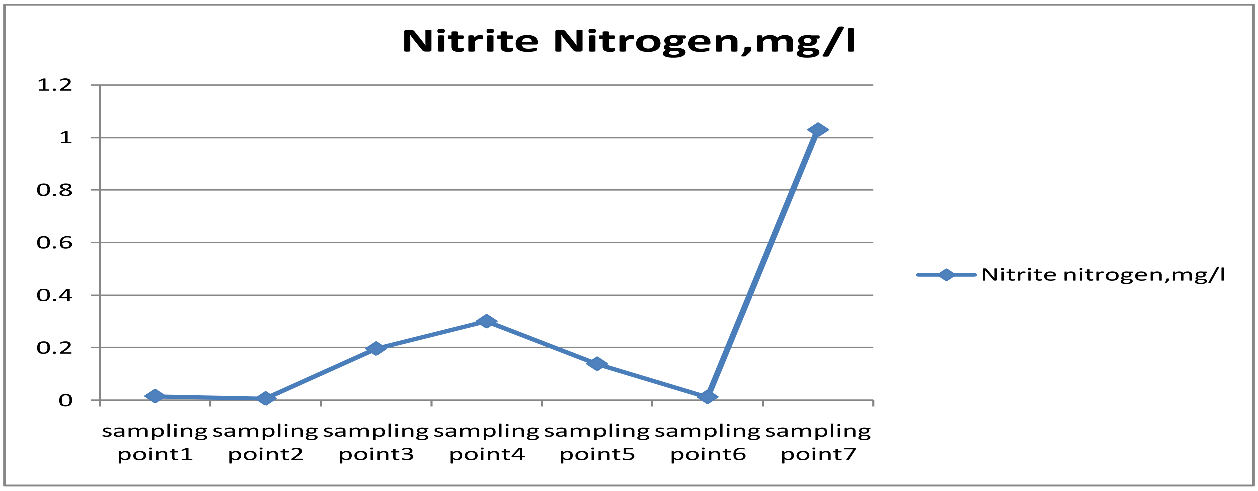
Nitrate Nitrogen: - When Nitrate Nitrogen converts into Nitrite Nitrogen in drinking water it becomes harmful. For both the process of Oxidation and Ozoneation, it depicts that in oxidation it was reduced up to 5mg/l max. and with Ozoneation by Colorimetric method it would be reduced nearer 2mg/l for all of seven samples, which is considered very good for drinking water.



Graph – 05 – Nitrate Nitrogen

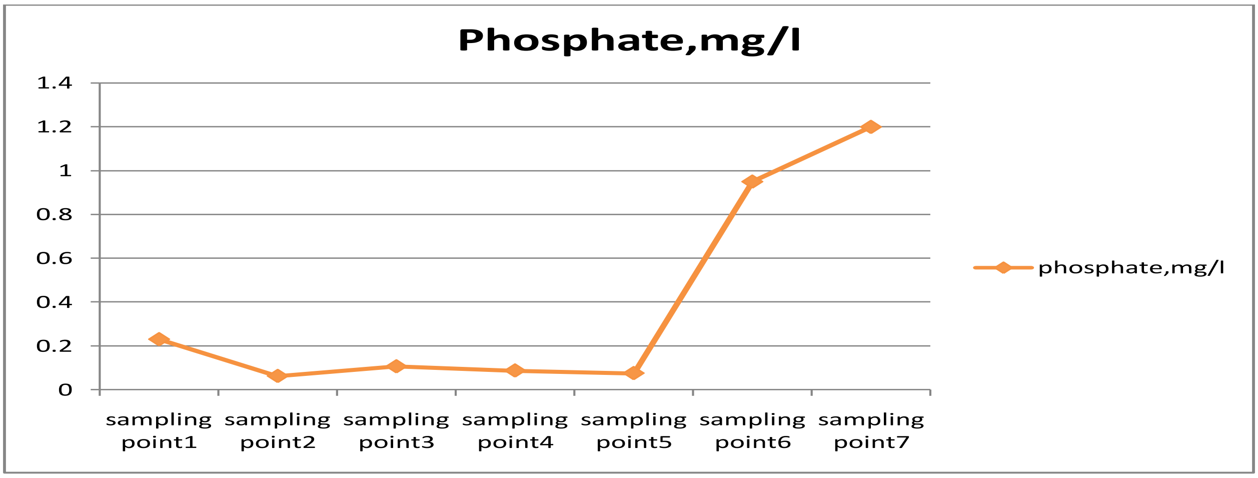
Nitrite Nitrogen: - Nitrite nitrogen is transformed form of Nitrate Nitrogen. It affects the human digestive system, it depicts the reduced as the drinking water had polluted, so that it is higher than

10mg/l and by Ozoneation this can be reduced up to 0.40 mg/l as well as by Oxidation by Colorimetric method it can be reduced up to 0.14mg/l every time and it seems good for water .



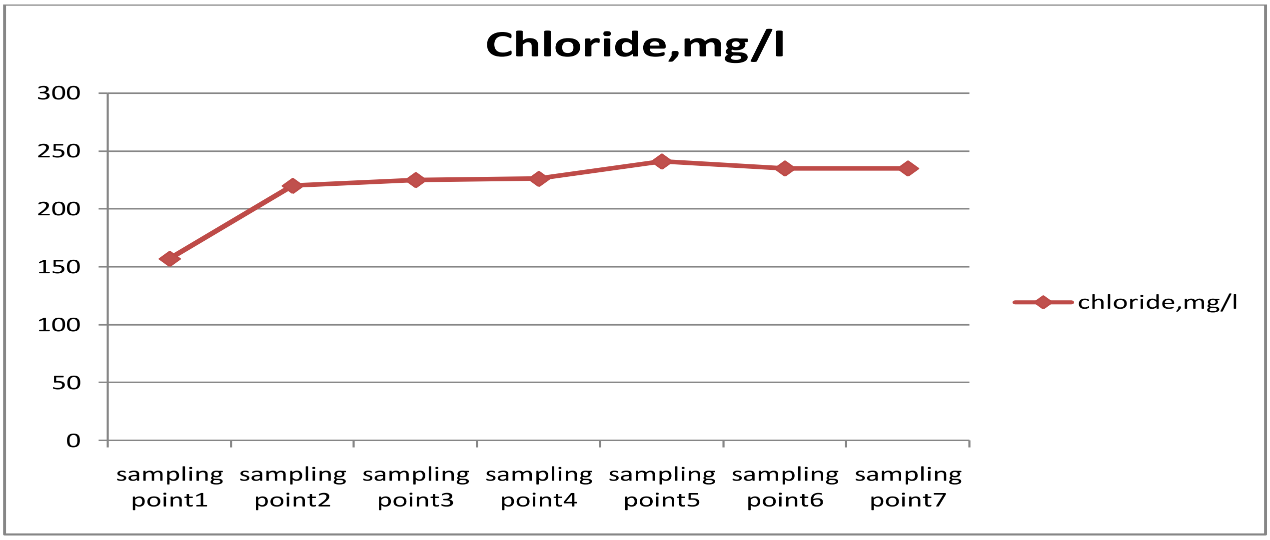
Graph – 06 – Nitrite Nitrogen

Phosphate: - In drinking water for the phosphate contaminant, we reduced it up to 1mg/l and more by Oxidation and with Ozoneation by AAS Method it was reduced these pollutants less than 1mg/l for each taken sample that depicts that it is better for drinking water.



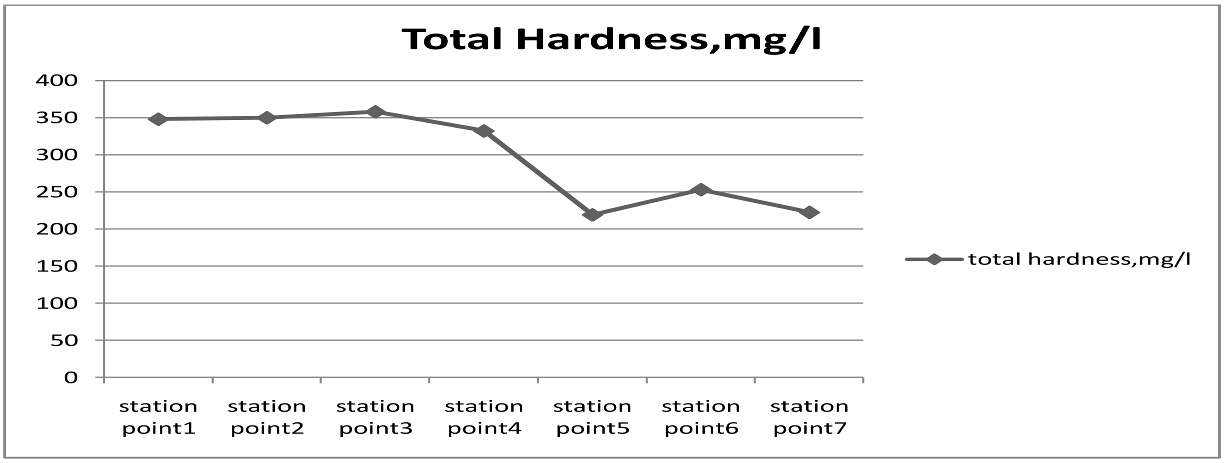
Graph – 07 – Phosphate

Chloride: - Excessive concentration of Chlorine in drinking water is unpleasant to drink. So that it depicts in above table and graph, that chloride removal with oxidation is high (close tom 230 mg/l) which is not so good and impact a salty taste at 250mg/l and from Ozoneation by AAS process these impurities of chloride from the water are eliminated. This elimination of minimize the quantity of chloride in every taken samples, nearer to 140mg/l, that can be considered best for drinking water.



Graph – 08 – Chloride

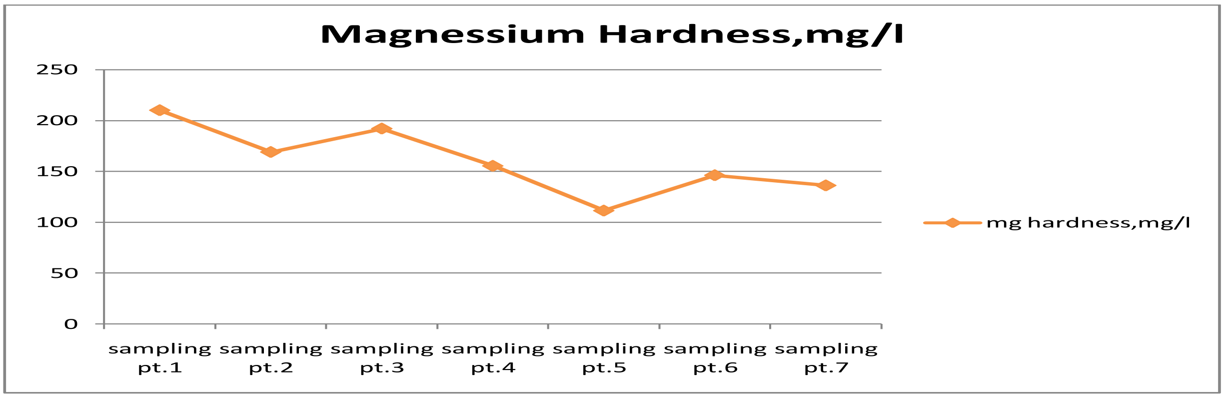
Hardness: - Total hardness are divided into two types:-
A). Temporary Hardness (Carbonates of Ca and Mg).
B). Permanent Hardness (Sulphates, Cl etc.).
Here it depicts that by Oxidation it decrease the carbonates and sulfates close to 350 mg/l. in which hardness of drinking water is very high and water is not so good to drink and from Ozoneation by AAS process it reduced these excessive contents close to 96 mg/l of all samples of water that is considered best for drinking.



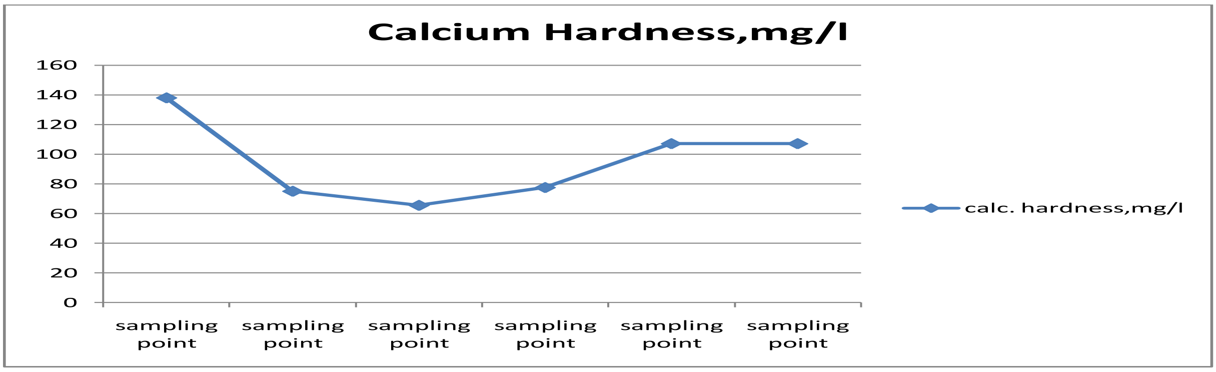
Graph – 09 – Total Hardness

Calcium Hardness & Magnesium Hardness: - This is depicts that Ca hardness is decreased as the drinking water was hard to use with Oxidation and by Ozoneation. The impurities from the drinking water are removed by which this type of hardness is decreases of each of seven samples taken by us. These all are close to 60mg/l and that is considered best for drinking water. Also it shows that with oxidation this hardness is reduced randomly with large variation that is unpleasant to drink and from

Ozoneation , the excess Mg impurities are eliminate from the water of all taken samples, nearer to 100 mg/l and this water sample can considered very good to drink

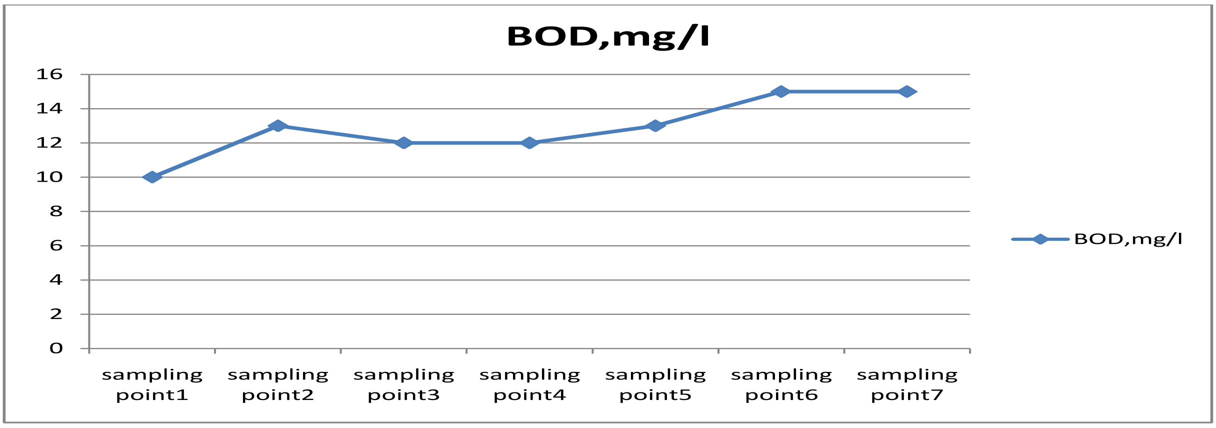


Graph – 10 – Magnesium Hardness



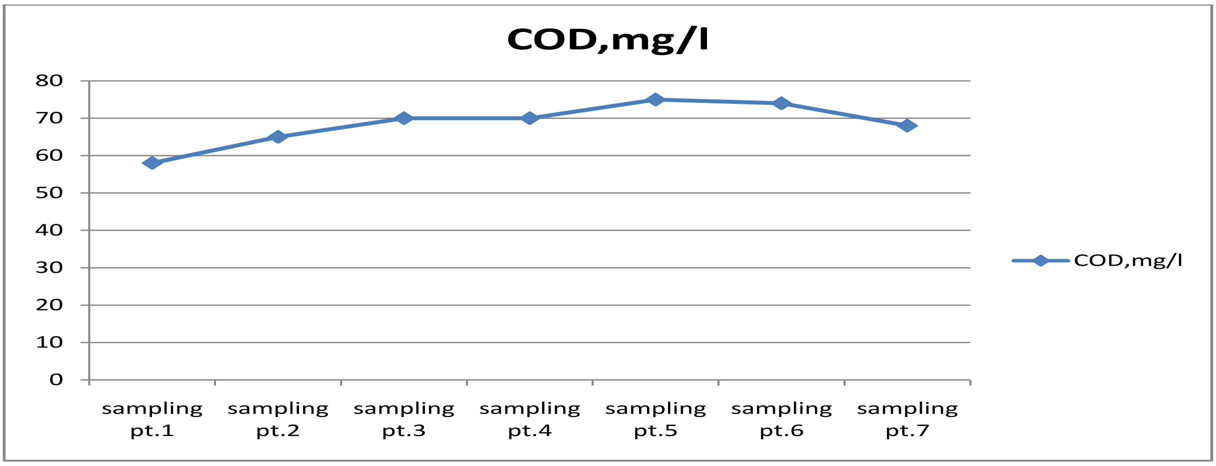
Graph – 11 – Calcium Hardness

Biochemical Oxygen Demand: - BOD level in drinking water should be 1 to 2 mg/l. If it is 6-9 ppm then drinking water considered somewhat contaminated. We depict that more than 100 ppm drinking water considered as much polluted. We depicts that with Oxidation process water having organic waste reduced the BOD level nearer to 15 mg/l and in Ozoneation by Dilution process the organic matter in sample was reduced which decreased the BOD level of all 7 sample close to less 5 mg/l in drinking water, which is considered best to drink.



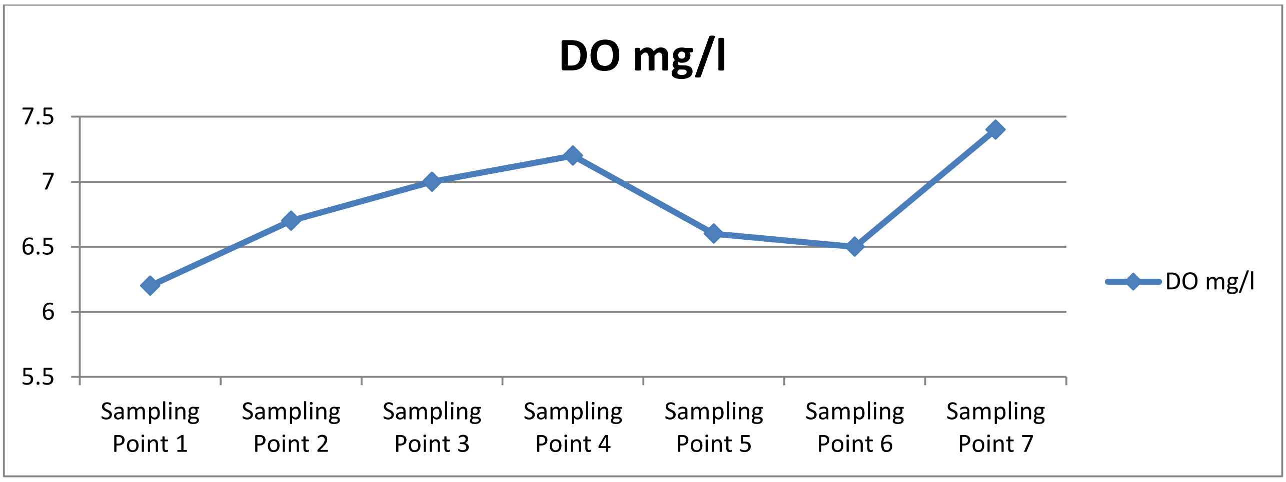
Graph – 12 – Biochemical Oxygen Demand

Chemical Oxygen Demand: - Chemical oxygen demand (COD) in drinking water should be >250 mg/l. Here it depicts that by oxidation it remarks 70 mg/l which can be somewhat polluted and with Ozoneation by Dilution process, these impurities were eliminated of all samples close to 40 mg/l and that can be prefer far better to drinking water.



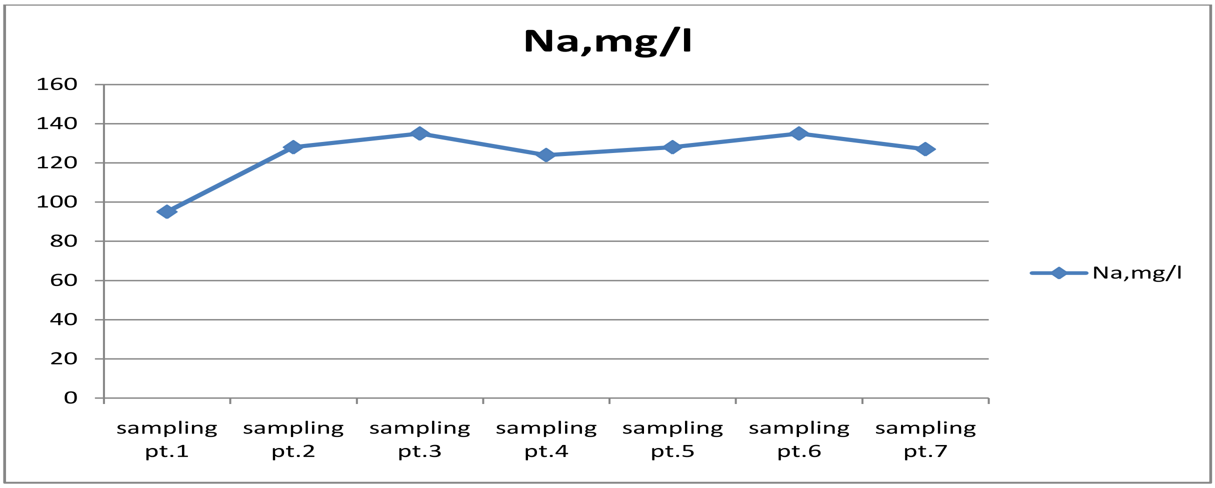
Graph – 13 – Chemical Oxygen Demand

Dissolved Oxygen: - Here we see in above table and graph also about the Dissolved Oxygen i.e. by Oxidation it is reduced close to 12 mg/l of each seven sample by that impurities are not eliminated properly and water was not so pure and in Ozoneation by BOD method dissolved oxygen reduced of every sample nearer to 6.0 mg/l, so that impurities are eliminated from the water sample and sample is considered best for drinking water.



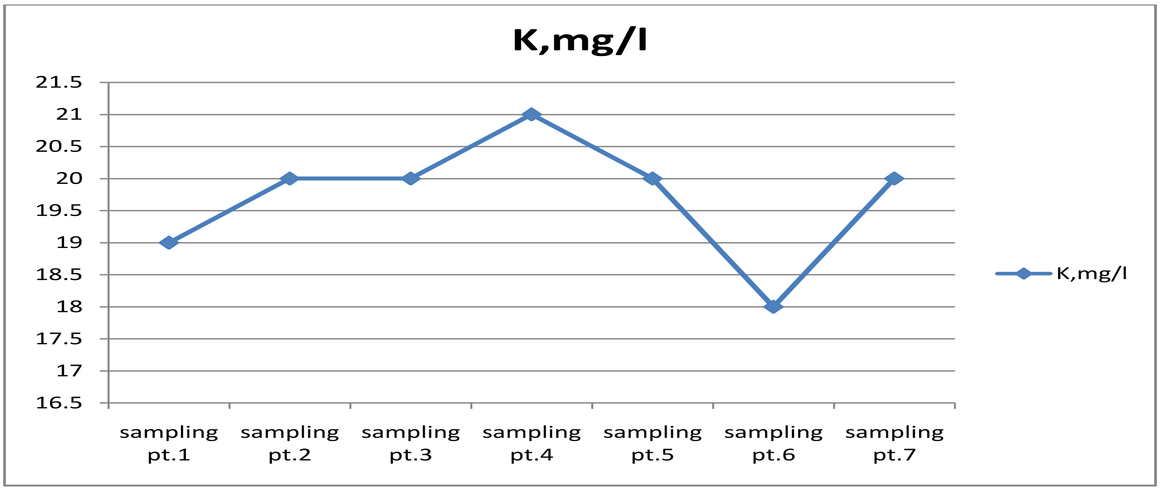
Graph – 14 – Dissolved Oxygen

Sodium :- Normally drinking water contents Na about 50 mg/l as the graph depicts that by Oxidation process Sodium Conc. in drinking water remarks all seven samples close to 125mg/l, so that it is not sufficient elimination of excess sodium impurities and in Ozoneation by AAS process the contaminants from the drinking water are eliminate, which reduced the Na concentration of each seven sample taken by us. These all remarks close to 115 mg/l, which is considered good.



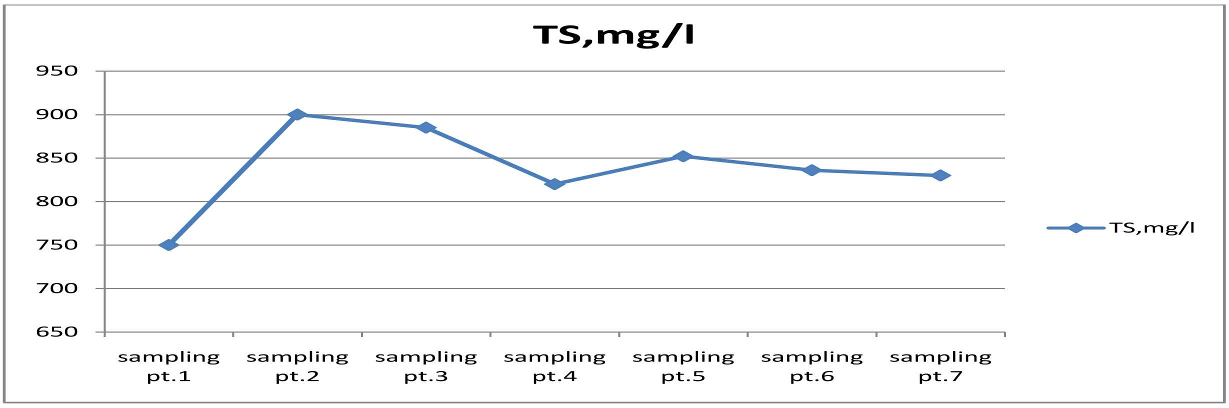
Graph – 15 – Sodium

Potassium :- For the Potassium it is not compulsory to establish a health based guide line value of K in drinking water, because in drinking water it is below the level 20 mg/l at which the harmful health effects may occur. Here the graph depicts that it reduced as the water was having impurities so that K was having variation in Oxidation which is not good to drink and by Ozoneation the contaminants from drinking water are eliminated which sets a good value of each and every of seven sample close to 15 mg/l, which is considered very good for drinking water.

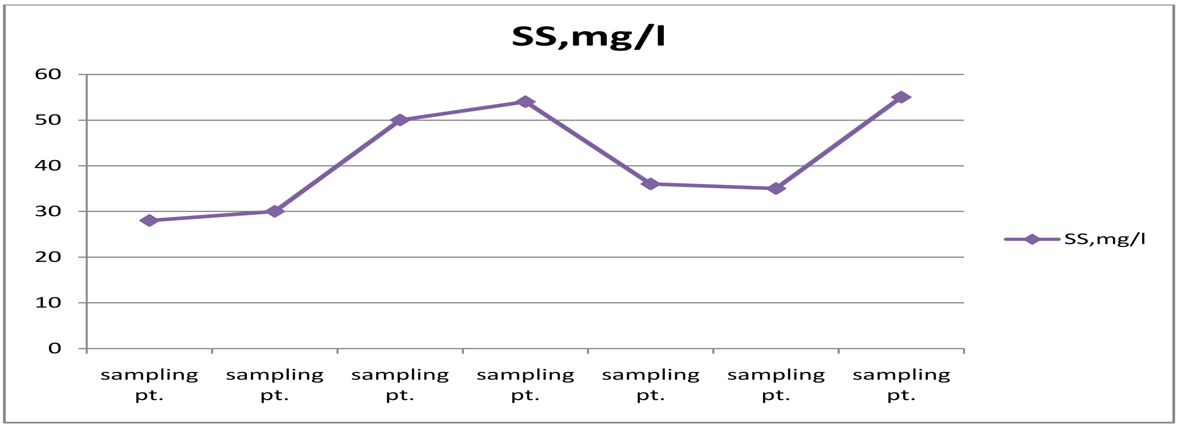


Graph – 16 – Potassium

Total suspended solids:- It includes the decomposed plants and animal matters etc. High concentration of suspended solids in drinking water may cause harmful problems. As in graph we shows the 7 sample stations, their results are occurring between 700-900 mg/l, which is not good enough to drink and by Ozoneation for each of seven samples we got results close to 400 mg/l, which can be considered far better for drinking water

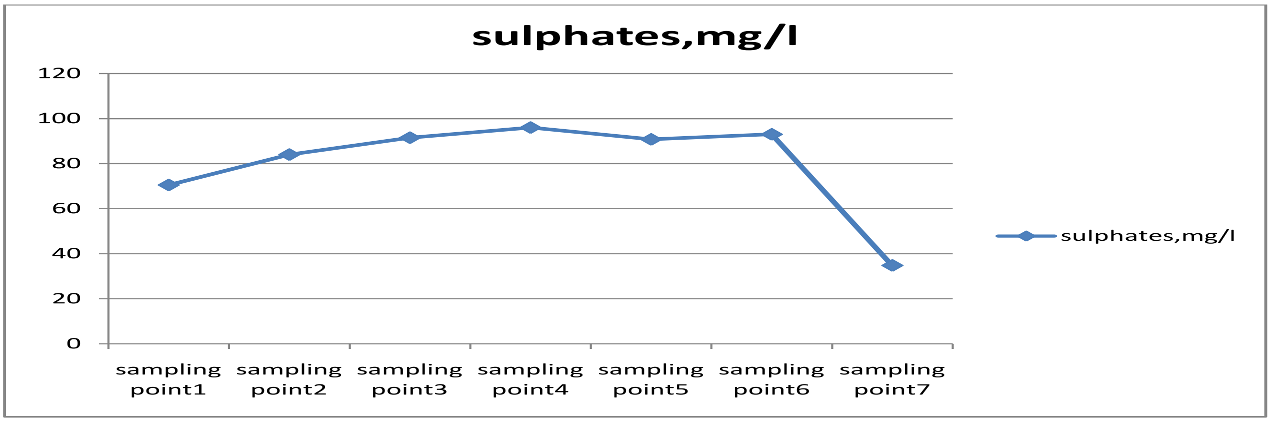


Graph – 17 – Total suspended solids



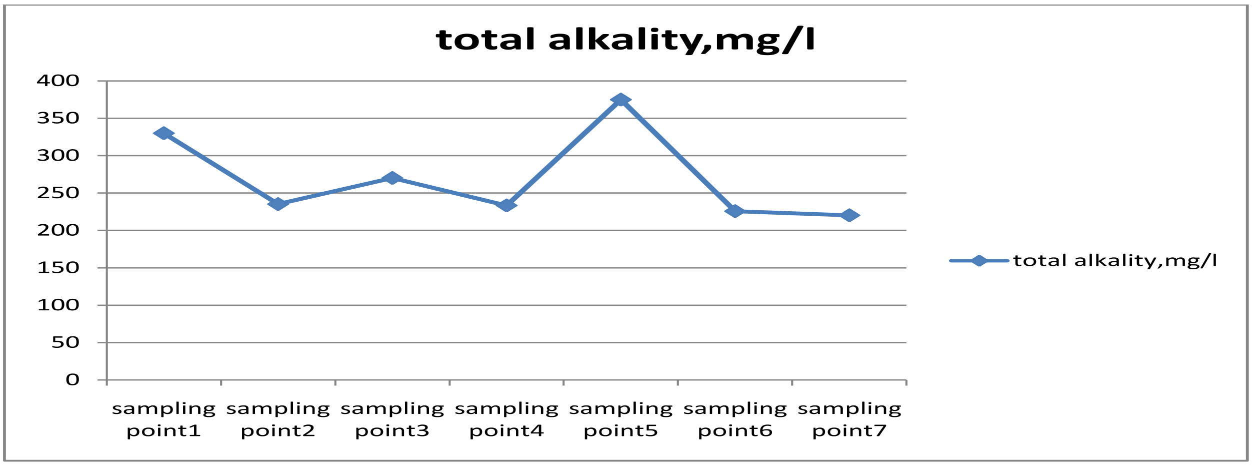
Graph – 18 – suspended solids

Sulphates:- It is one of the majored dissolved component of the rain water. In drinking water normally its level should not be greater than 250mg/l. In given below graph we shows the different readings of samples, at which got remarks around 90 mg/l, and by Ozoneation from AAS method it remarks close to 45 mg/l, which is more better for drinking water.



Graph – 19 – Sulphates

Alkalinity:- Alkalinity is an important in explaining a stream's capability to neutralize the acidic pollution by rainfall or waste water. It does not refer to pH level, it but instead refers to the ability of water to resist change in pH. In above graph we shows the different station points of samples by oxidation, which depicts that it has results between 220 to 400 mg/l by which ph level may be high and by Ozoneation we find that for all seven samples it remarks nearer to 150 mg/l which is enough for able to balance the pH level in water and make it good for drinking.



Graph – 20 – Alkalinity

ATOMIC ABSORPTION SPECTROSCOPY (AAS) :-

A procedure of spectra analytical for the determination of chemical elements by the using of absorption of optical radiation or light by free atoms in the gaseous state. Here we used it for the determination of concentration of a particular element of water sample.

Pilot tests with the two different types of ozone reactors, in which one is present for very short residence time and a classical bubbles column with a porous diffusers where it conducted simultaneously with the same water sample in order to evaluate the influence of the residence time on disinfection efficiency.

As the graph it depicts about the removal of and reduction of absorbance, we can see in the graph (a), the square dots represents the % of COD and the circle dots represents the % of absorbance. The graph shows as the ozonation process take time the % of reduction of COD is increasing randomly. And after 40 minutes when reduction of ozone reaches at above 40% it seems to be increasing the COD removal linearly.

Similarly, absorbance reduction is increasing slightly randomly till 20 minutes and after 20 mins. It is increasing constantly.

For secondary effluents with poor quality and high total solid solvent and COD, more stringent requirements would be difficult to consistently meet even at very high TOD's of 25-30 mg/L. To achieve less than 200 FC(fixed carbon) or E. coli/100 mL. Tertiary filtration appears as necessary, enabling to achieve the stringent requirements and low TOD (total oxygen dissolved) of 5 to 10 mg/L. this type of results were also obtained by Liberti et al. (2000) in the clarified secondary effluents, for the WHO guidelines with increase the ozone dose of 15 mg/L and HRT of 10 min. For the same disinfection objective sample, tertiary filtration enabled to decrease ozone dose by 50% down to 7 mg/L.

When compared to other drinking water treatment alternatives, such as air stripping and activated carbon, AOP (advanced oxidation process) is an emerging technology. Presently, there are only a few cases where organic contaminants as like PCE and NDMA are being removed from drinking water using an AOP.

To assess the Ozoneation processes with respect to oxidation by ozone and OH radicals, the concentrations or the exposures to both oxidants have to be known. Ozone concentrations can be easily measured by electro chemical, optical or colorimetric methods.

Table3- Water Quality based determination of Ozone Point application for drinking water treatment :-

Demand of ozone	**Water characteristics**	**turbidity**	**Where to add**	**reason**
low	Raw water	Low	Raw water	For only practical purpose
Low	Inorganic materials(clay, slit)	high	After pre-sedimentation	Decrease ozone demand
High	Dissolved constituents (Br, Fe, Mg…)	low	Raw water	Biological treatment for bio degradable organics
High	High conc. Of inorganic material	high	After sedimentation & filtration	Very high organic may requirement biological treatment

In above table we mention about the demand of ozone in purification of drinking water treatment. Here the demand of ozone is low for raw water and water having inorganic materials like clay, slit etc. in this condition the turbidity is low for raw water and high for water having inorganic materials. These characteristics are for only practical purpose. The water having dissolved constituents as such as Br, Fe, Mg, and high conc. Of inorganic materials needs high demand of ozone dose. We also show where (after which process) ozone should be added.

Conclusion

When we compare oxidation, especially using chlorine-based methods, with ozonation, clear differences emerge. Oxidation is cost-effective and provides lasting protection in pipes, but it can form unwanted by-products. Ozonation, while more expensive and complex, offers superior microbial killing and fewer halogenated by-products, though it needs a secondary disinfectant.

The samples are taken across Ujjain city and these samples are taken on a single day so temperature fluctuations are minimum. The turbidity is highest in sample 1 as well as pH. The DO ranges well from 6mg/L to 7.2 mg/L. the COD and BOD are well within limits of drinking water. All parameters in ozonized water are well within drinking water limits.

Choosing the right method depends on many things: what's in your raw water, what specific problems you need to solve, and local regulations. Both oxidation and ozonation are vital tools for clean water.

The best strategy often involves using a blend of treatments, creating a strong multi-barrier defense. This layered approach ensures that every drop of water we drink is as safe and clean as possible. It's how we protect public health, one glass of water at a time.

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