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Pretreatment of Water for Industrial Boilers Purposes, Alexandria

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Abstract: Some power plants use sand filtering, ion exchange, and chemical decarbonization to create boiler water. Ion exchange in a mixed bed completes this procedure. On the basis of the water quality that is attained, the amount and quality of the water, and the necessary chemical dosages, the current boiler water treatment processes are assessed. The extensive usage of chemicals in present systems is a serious flaw. Reverse osmosis can take the role of the ion exchange process; however, pretreatment (decarbonization and filtering) must still be used. This investigation's goal is to assess how well pretreated water performs in the boiler unit of a food processing facility in Borg El Arab, Alexandria, Egypt. Oxygen scavengers like sulfites, tannins, DEHA, and carbohydrazides, flocculants like poly-aluminum chloride and aluminum sulphate (liquid), and lime scale inhibitors like polyphosphates, hexametaphosphates, and polyphosphates are all the subject of current research. Salt or another flocculating agent was utilised. Results indicated that, when compared to other oxygen scavengers utilized in the study, alum coagulant, polyphosphate mineralizer, and carbohydrazide were more efficient than PAC.

Keyword: Water treatment, Boiler, corrosion, scales, Alexandria city.

Introduction:

To completely comprehend what has to be treated, a fundamental examination of boiler feed water is first needed. All consumables contain three main categories of pollutants, each of which can impact boilers and stoves differently. Dissolved gases, dissolved solids, and suspended particles make up these pollutants. Water absorbs contaminants from the soil it comes into touch with and the air it passes through. Both flow velocity and contact time have an impact on the contamination type. Depending on the amount of rainfall and where it falls in the basin, the water's characteristics alter over the course of the year. Groundwater and surface water are the two primary sources of water. More dissolved solids and less gas and suspended particles are often found in groundwater. Surface water frequently has more dissolved gases and suspended solids than dissolved solids (1).

Ultrapure water is used in enormous quantities in power plants. Demineralized water is produced with great care for usage as process water and boiler feed water. The amount of process water needed means that water treatment must be quick, simple, low energy, chemically demanding, and economical. Usually, the amount and quality of wastewater generated by these water treatment operations are not taken into account. This study examines the quantity and kind of wastewater produced during the manufacture of desalinated water utilising reverse osmosis and ion exchange, with a focus on raw water and chemical utilisation(1, 2).

The quality of the feedwater that enters a boiler system is similar in many ways to the nutrients that provide energy for your body. If you ingest the right nutrients and maintain a balanced diet, you often feel fine. But if you consume something unpleasant, you might feel bad; Maintaining a harmful habit could lead to later, more significant problems. Both procedures make use of the same tools. To protect the wellbeing of systems, the American Society of Mechanical Engineers (ASME) has created feedwater quality norms. Pretreatment is the cornerstone of every system, thus it is crucial that it performs well and supplies feedwater of the greatest standard. Higher scale and corrosion levels, lower equipment life, and other issues will affect your downstream equipment. The most crucial thing you can do to increase efficiency is to do routine maintenance on all pretreatment equipment (3, 4).

Some of the more common chemicals used to treat boiler water include:

- Coagulants.
- Phosphates.

- Oxygen scavengers.
- Chelants.

Coagulants: To cause any suspended particles to adhere to one another or flocculate, boiler water can be treated with ferric chloride or hydrated potassium aluminium sulphate (more commonly referred to as "alum"). When the boiler is being blown down, these larger impurity clusters, also known as sludge, float through the water and settle at the bottom of the boiler (5, 6).

Phosphates: Despite the fact that the coagulation process clears the water of suspended impurities, caustic sludge clumps that build up on the bottom of the boiler can still harm the machinery. By adding sodium phosphate to the water, which regulates the material's pH and aids in preventing harmful caustic corrosion, this problem can be solved (5, 6 and 7).

Oxygen Scavengers: The longevity and efficiency of the boiler will be improved by eliminating any surplus oxygen from the water because oxygen is a key factor in metal corrosion. Oxygen scavengers, such as sodium sulfite or hydrazine, can be employed in this situation to assist remove oxygen and stop harmful corrosion (7, 8).

Chelants: In order to prevent the production of insoluble solid precipitates, these molecules interact with positively charged metal ions in certain ways. Nitrilotriacetic acid (NTA) and ethylenediaminetetraacetic acid (EDTA), the two most utilised chelants for water treatment, are used to create complex ions with calcium and magnesium in the water. According to the theory, the chelant sequesters the metal ions to prevent scale formation in the boiler (9, 10).

Operators of power-generating boilers must be aware of any potential problems that may develop when superheated water is necessary for the operation, in addition to knowing which chemicals function best with the contaminants contained in typical boiler water. Water that is used under pressure and at temperatures between the ordinary boiling point of 212°F (100°C) and the critical temperature of 700°F (370°C) is referred to as superheated water (11, 12).

Since superheated water can be more corrosive than conventional water at temperatures beyond 570°F (300°C), special consideration must be given to its operational characteristics. As a result, extra care must be given when choosing building materials, such as the chemicals that may be required to treat the water (carbon steel and stainless steel pipes have shown to be efficient in these circumstances) (12 13).

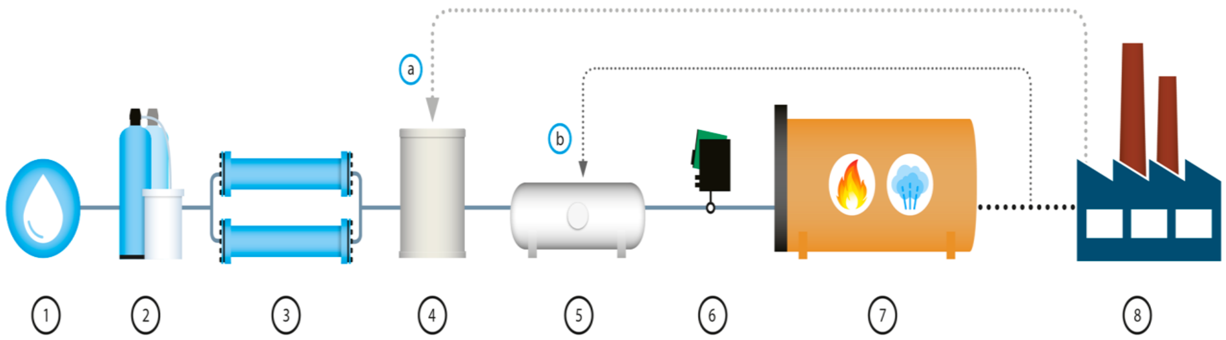
The optimum solution for industrial boiler water treatment

An ideal boiler water treatment system includes a pressure filter, softening plant, reverse osmosis unit, and thermal deaerator in order to guarantee the flow of high-purity feedwater and make-up water.

When regular hard mains water is used as make-up water for steam boilers, lime stone will accumulate on the heating surface of the boiler. As more energy is wasted, more acid is therefore needed to clean the boiler's interior (14).

Although water softening avoids scaling, the softening plant has no issues with the bicarbonate concentration of the raw water. The requirement for blow down increases as the bicarbonate in the boiler splits into caustic condensate, carbon dioxide (CO_2), and sodium hydroxide (NaOH). By demineralizing the make-up water with a reverse osmosis plant or a two-column ion exchange system, followed by degassing with a thermal deaerator, the issue can be remedied (15).

Fig. 1: Feed Water Pretreatment for Boilers



1. Raw water
Pressure filtration of raw water.
Removal
Iron (Fe^{++})
Manganese (Mn^{++})
2. Softening
Softening by ion exchange.
Removal
Calcium (Ca^{++})
Magnesium (Mg^{++})
3. Demineralization
Demineralized water by reverse osmosis.
Removal
98 % salts
Potassium (K^+)
Sodium (Na^+)
Chloride (Cl^-)
Nitrate (NO_3^-)
Sulphate (SO_4^{--})
Silicic acid (SiO_4^-)
Alkalinity (HCO_3^-)
4. Water tank
Storage of the demineralized water.
5. Degassing
Removal of gasses with a thermal deaerator.
Removal
Carbon dioxide (CO_2)
Oxygen (O_2)
6. Dosing pump
Pump for dosing of chemicals to maintain boiler operation.
7. Steam boiler
The water is heated to create high quality steam.
8. Production
Condensed water is lead to the water tank (a). Steam for preheating is lead to the thermal deaerator (b).

This study's objective is to assess how well pretreatment water for boiler units in the food industries in Borg El Arab, Alexandria, Egypt.

Methodology:

- **Sampling**

The water samples were collected during the period of study (Jan. to Feb. 2023), the samples were analyzed in central laboratory of AWCO, Alexandria city. The water samples were analyzed according to APHA, 2017 (26).

- **Material**

In the present study the coagulants used were poly-aluminum chloride and aluminum sulphate (liquid) and the anti-scalant used were hexa-meta-phosphate and poly-phosphate and the oxygen scavengers used were sulphite, tannin, DEHA and Carbohydrazide.

Results & Discussion:
Coagulants:

1. **Alum:**

The effectiveness of the boiler's pre-treatment of the feed water with alum at various doses was investigated in the current study, as shown in Table (1) and Fig. (2). The monitoring of the alum dosages showed that the pH, organic content (TOC), and alkalinity of the treated water all dropped as alum doses increased, as well as the suspended particles. However, as shown in Table (1) and Fig. (2), the saturation index (LSI) data demonstrated that corrosive water is indicated by an LSI value of less than -0.5.

Table (1): Effect of Alum dose on the feed water quality

No.	**Water parameters**	**Unit**	**Alum Conc. (mg/l), The feed water treated by resin (softener), and Oxygen scavenger (Nitrite)**											
			6	**8**	**10**	**12**	**14**	**16**	**18**	**20**	**Avg.**	**Min.**	**Max.**	**Sd.**
01	pH	-	7.7	7.5	7.4	7.3	7.2	7.1	7.02	7.01	7.3	7.0	7.7	0.2
02	Suspended Solids	mg/l	0.6	0.6	0.5	0.4	0.4	0.3	0.2	0.2	0.4	0.2	0.6	0.2
03	Total Hardness	mg/l	3	3	3	3	3	3	3	3	3.0	3.0	3.0	0.0
04	Calcium hardness	mg/l	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	0.0
05	Magnesium hardness	mg/l	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	0.0
06	Iron	mg/l	0.031	0.028	0.028	0.026	0.021	0.021	0.02	0.015	0.0	0.0	0.0	0.0
07	Manganese	mg/l	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.0	0.0	0.0	0.0
08	Ammonia	mg/l	0.2	0.19	0.18	0.18	0.17	0.17	0.16	0.14	0.2	0.1	0.2	0.0
09	Aluminium	mg/l	0.13	0.15	0.16	0.18	0.19	0.2	0.22	0.23	0.2	0.1	0.2	0.0
10	DO	mg/l	1.1	1.1	1.08	1.06	1.06	1.08	1.08	1.07	1.1	1.1	1.1	0.0
11	CO_2	mg/l	0.41	0.42	0.4	0.38	0.39	0.38	0.37	0.39	0.4	0.4	0.4	0.0
12	TDS	mg/l	552	556	558	564	565	566	572	584	564.6	552.0	584.0	9.4
13	Silicates	mg/l	4.2	4.3	4.1	4.1	4.2	4.3	4.4	4.2	4.2	4.1	4.4	0.1
14	Alkalinity	Mg/l	122	118	114	112	108	104	98	96	109.0	96.0	122.0	8.7
15	TOC	mg/l	4.8	4.1	3.4	3.1	2.8	2.2	1.9	1.6	3.0	1.6	4.8	1.0
LSI			-3.02	-3.22	-3.32	-3.42	-3.57	-3.69	-3.79	-3.81				

Sd.: Standard Deviation.

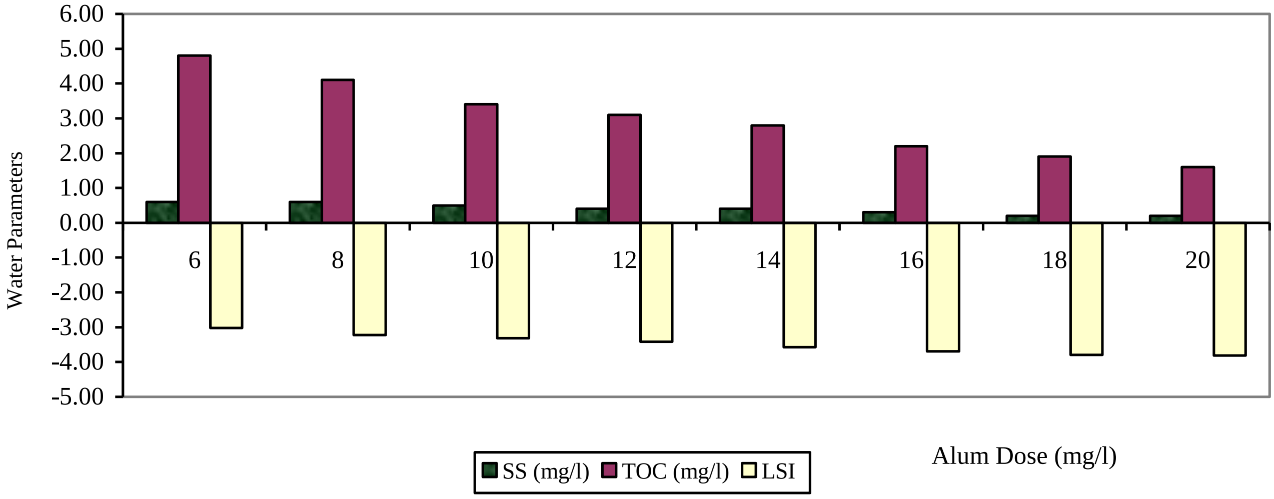


Fig. (2): Effect of Alum dose on the feed water quality

2. PAC:

The current study studied the poly-aluminium chloride (PAC) doses used in the boiler's feed water pre-treatment, as shown in Table (2) and Fig. (3), along with the evaluation of the efficiency. According to Table (2) and Fig. (3), corrosive water has an LSI value lower than -0.5. The monitoring of the PAC doses showed that the suspended particles and the organic content (TOC) of the treated water both decreased as the PAC doses increased. The pH or alkalinity of the treated water did not change as a result of the PAC treatment.

Table (2): Effect of PAC dose on the feed water quality

No.	**Water parameters**	**Unit**	**PAC Conc. (mg/l), The feed water treated by resin (softener), and Oxygen scavenger (Nitrite)**											
			0.5	**1.0**	**1.5**	**2.0**	**2.5**	**3.0**	**3.5**	**4.0**	**Avg.**	**Min.**	**Max.**	**Sd.**
01	pH	-	7.8	7.78	7.79	7.78	7.78	7.79	7.77	7.78	7.8	7.8	7.8	0.0
02	Suspended Solids	mg/l	0.6	0.5	0.4	0.3	0.2	0.2	0.2	0.1	0.3	0.1	0.6	0.2
03	Total Hardness	mg/l	3	3	3	3	3	3	3	3	3.0	3.0	3.0	0.0
04	Calcium hardness	mg/l	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	0.0
05	Magnesium hardness	mg/l	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	0.0
06	Iron	mg/l	0.026	0.022	0.019	0.018	0.014	0.012	0.01	0.01	0.0	0.0	0.0	0.0
07	Manganese	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.0	0.0	0.0	0.0
08	Ammonia	mg/l	0.2	0.2	0.19	0.18	0.17	0.17	0.16	0.14	0.2	0.1	0.2	0.0
09	Aluminium	mg/l	0.06	0.05	0.04	0.04	0.05	0.04	0.04	0.04	0.0	0.0	0.1	0.0

No.	**Water parameters**	**Unit**	**PAC Conc. (mg/l), The feed water treated by resin (softener), and Oxygen scavenger (Nitrite)**											
			0.5	**1.0**	**1.5**	**2.0**	**2.5**	**3.0**	**3.5**	**4.0**	**Avg.**	**Min.**	**Max.**	**Sd.**
10	DO	mg/l	1.1	1.1	1.1	1.07	1.06	1.08	1.08	1.07	1.1	1.1	1.1	0.0
11	CO_2	mg/l	0.39	0.4	0.4	0.39	0.39	0.38	0.37	0.39	0.4	0.4	0.4	0.0
12	TDS	mg/l	551	552	559	558	565	565	568	569	560.9	551.0	569.0	6.5
13	Silicates	mg/l	4.1	4.1	3.8	3.7	3.7	3.6	3.6	3.5	3.8	3.5	4.1	0.2
14	Alkalinity	Mg/l	122	122	122	120	120	120	119	119	120.5	119.0	122.0	1.2
15	TOC	mg/l	4.7	3.9	3.8	3.1	2.6	2.4	1.8	1.4	3.0	1.4	4.7	1.1
LSI			-2.92	-2.95	-2.96	-2.96	-2.96	-2.96	-2.96	-2.96				

Sd.: Standard Deviation.

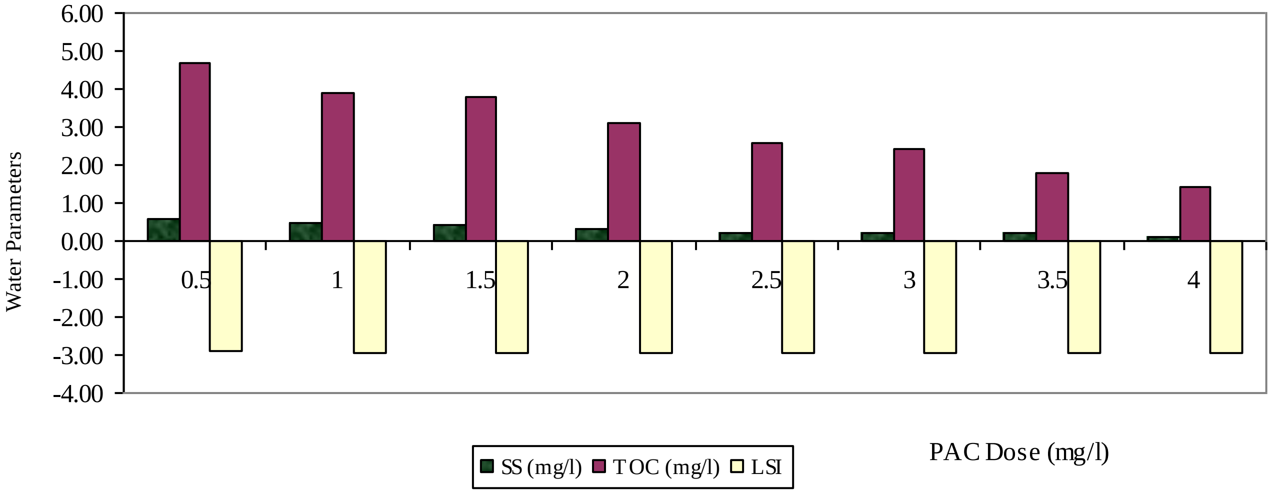


Fig. (3): Effect of PAC dose on the feed water quality

Antiscalant:

1. Hexametaphosphate:

According to Table (3) and Fig. (4), the efficiency of the Hexametaphosphate pre-treatment of the boiler's feed water at various doses was examined in the current study.

As shown in Table (3) and Fig. (4), the saturation index (LSI) data demonstrated that as the quantity of hexametaphosphate increased, the treated water became more acidic and higher corrosive with no chance of producing scales. Corrosive water is indicated by an LSI value less than -0.5.

A key element in the production of scale is the chemistry of the feed water. The most common types are silica-based scales, non-alkaline scales (like $CaSO_4$), and alkaline scales (like $CaCO_3$). The most common component of scale, $CaCO_3$, is formed when calcium and bicarbonate ions interact in surface water, groundwater, brine, and industrial water. Other scale-forming salts contain a number of compounds with limited solubility in water, such as $MgCO_3$, BaSO4, $Fe_2(CO_3)_3$, iron oxides, silicates, fluorides, and phosphates. The three crystal forms that develop from the common hardness, or $CaCO_3$, as it crystallises are calcite, aragonite, and vaterite (16, 17).

Scales made of argonite and vaterite are often softer and easier to remove than those made of calcite. $CaSO_4$ and $Ca_3(PO_4)_2$ are typical scale elements in groundwater and wastewater, respectively. Amorphous silicic acid [$Si(OH)_4$] containing Al, Fe, Mg, and Ca is the most prevalent hydroxide form of metal found in silica and silicates. The silica coating produced by the supersaturation and polymerization of soluble silica is sticky and difficult to remove (18, 19).

Antiscalants are a class of chemicals designed to stop the precipitation and development of scale-forming mineral salt crystals. Anionic polymers, polyacrylic acids, carboxylic acids, polymaleic acids, organophosphates, and polyphosphates are only a few examples of the proprietary organic man-made polymers that make up the majority of antiscalants. The molecular weights of these polymers can range from 2000 to 10,000 Da. (20, 21).

Table (3): Effect of hexa-meta-phosphate dose on the feed water quality

No.	Water parameters	Unit	HMP Conc. (mg/l), The feed water treated by resin (softener), and Oxygen scavenger (Nitrite)											
			0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	Avg.	Min.	Max.	Sd.
01	pH	-	7.3	7.1	6.8	6.5	6.2	5.8	5.4	5.2	6.3	5.2	7.3	0.7
02	DO	mg/l	0.6	0.6	0.5	0.5	0.6	0.5	0.5	0.5	0.5	0.5	0.6	0.0
03	CO_2	mg/l	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.2	0.3	0.0
04	Alkalinity	Mg/l	84	80	72	64	60	58	58	56	66.5	56.0	84.0	10.1
05	TOC	mg/l	4.4	4.3	4.3	4.2	4.3	4.2	4.2	4.2	4.3	4.2	4.4	0.1
LSI			-3.58	-3.80	-4.15	-4.50	-4.83	-5.24	-5.64	-5.86				

Sd.: Standard Deviation.

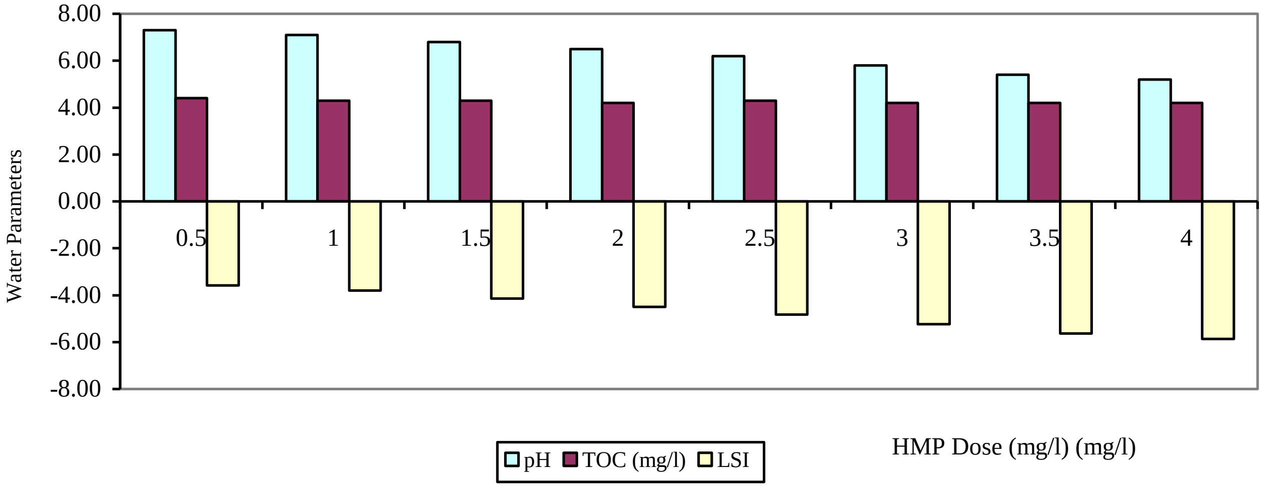


Fig. (4): Effect of HMP dose on the feed water quality

2. Polyphosphate:

According to Table (4) and Fig. (5), the efficiency of the polyphosphate doses utilised in the pre-treatment of the boiler's feed water was examined in the current study.

As the concentration of polyphosphate increased, the treated water became more acidic and more corrosive with no chance of producing scales, according to the saturation index (LSI) values, as shown in Table (4 and Fig. 5). According to the values of the saturation index (LSI), corrosive water has an LSI value less than -0.5.

Hardness salts can be treated inside the boiler using the appropriate antiscalants or scale inhibitors, or they can be removed from the boiler system before they enter. Even when hardness has been eliminated from the make-up water, using an efficient scale management strategy in the boiler water is essential to preventing any hardness slippage from producing troublesome deposits (22, 23).

In order to precipitate the magnesium and calcium hardness salts as hydroxyapatite and serpentine, boiler make-up water is treated with polymer phosphate. These substances form sludge when adequately condition with polymers, which is removed from the boiler during blowdown. By keeping a sizable surplus of soluble orthophosphate and free hydroxide (caustic) alkalinity in the boiler water, calcium carbonate formation can be all but prevented. Polymeric dispersants or sludge conditioners are added along with the phosphate to condition the sludge for easier evacuation from the boiler (15, 24).

Pre-treatment steps are necessary to reduce scale formation, as shown in Table (4). These techniques frequently involve softening, pH adjustment, and the use of membranes with larger hole sizes. Scaling during the subsequent membrane process can be prevented by removing scale-forming components like Ca2+ and Mg2+ utilising lime softening and ion exchange softening. The development of some types of sparingly soluble salts can be avoided by altering the pH of feed water since the solubility of carbonate minerals and silica scale is closely linked to pH (14, 19).

Table (4): Effect of Polyphosphate dose on the feed water quality

No.	**Water parameters**	**Unit**	**PP Conc. (mg/l), The feed water treated by resin (softener), and Oxygen scavenger (Nitrite)**											
			0.5	**1.0**	**1.5**	**2.0**	**2.5**	**3.0**	**3.5**	**4.0**	**Avg.**	**Min.**	**Max.**	**Sd.**
01	pH	-	7.1	6.8	6.5	6.2	5.8	5.6	5.1	4.8	6.0	4.8	7.1	0.8
02	DO	mg/l	0.5	0.6	0.5	0.5	0.6	0.5	0.5	0.5	0.5	0.5	0.6	0.0
03	CO_2	mg/l	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.2	0.3	0.0
04	Alkalinity	Mg/l	80	78	70	62	58	56	56	52	64.0	52.0	80.0	10.0
05	TOC	mg/l	4.2	4.1	4.2	4.1	4.0	4.0	4.0	4.0	4.1	4.0	4.2	0.1
LSI			-3.80	-4.11	-4.46	-4.81	-5.24	-5.46	-5.96	-6.29				

Sd.: Standard Deviation.

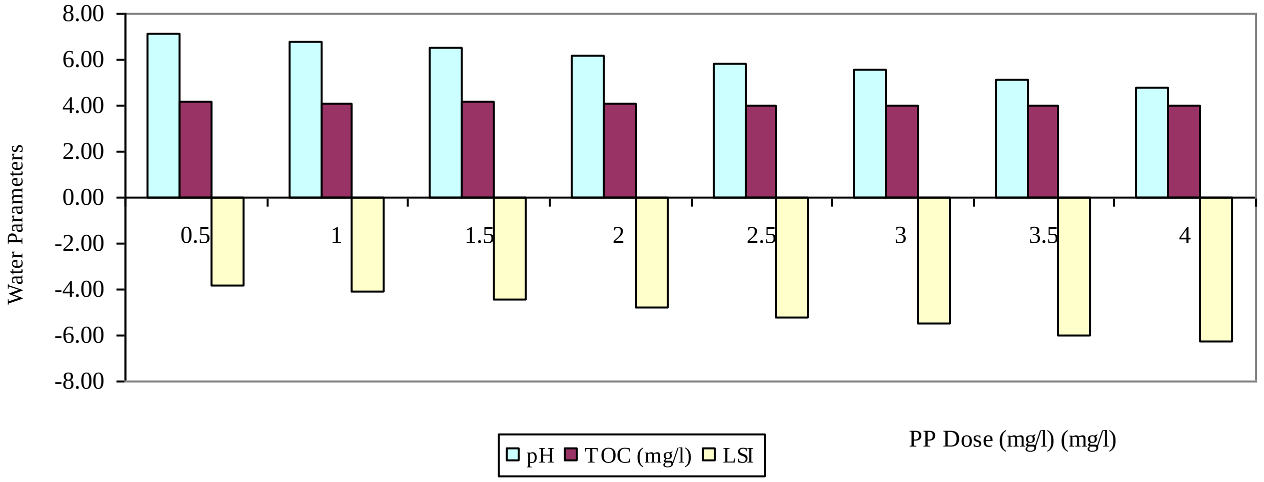


Fig. (5): Effect of PP dose on the feed water quality

Oxygen scavengers & anticorrosion:

Sulphite:

According to Table (5) and Fig. (6), the efficiency of the pre-treatment of the boiler's feed water with sulphite at various concentrations was examined in the current study.

The values of dissolved oxygen (DO) showed that as sulphite doses increased, the treated water became less oxygenated and lacked any corrosive potential, as shown in Table (5) and Fig. (6).

Controlling oxygen corrosion is necessary to ensure the dependability of steam generation systems. Mechanical deaeration and chemical oxygen scavenging are useful techniques for decreasing oxygen levels in boiler feedwater systems. The use of sulfites in the boiler feedwater circuit to reduce oxygen and prevent corrosion is also examined in this paper in addition to covering mechanical and operational oxygen reduction approaches. The principles underpinning mechanical deaeration, oxygen pitting, and electrochemical processes are all covered. A deaerator troubleshooting guide and estimating methods for the required steam production are also provided. The chemistry of sulfites is explored in detail. The many types of chemical oxygen scavengers are also described, along with a functional definition (3, 8).

The maximum dissolved oxygen limit for monoethylene glycol (MEG), which is used as a gas hydrate inhibitor, is normally set between 10 and 20 ppb. By having leaks or being exposed to poor-quality blanket gas, oxygen levels up to 1000 ppb may be produced. Scavenging for oxygen is an intriguing method of reducing the concentration, however OSs designed for water treatment have limitations in MEG solutions. They react slowly in MEG at low temperatures when the pH is less than 9, and some of them are incompatible with other industrial chemicals (11, 18).

A screening of commonly used reducing agents in lean (90%) MEG at a pH of around 8 revealed that erythorbic acid performed better than the alternatives. The employment of diethylaminoethanol (DEAE) and manganese (II) as a catalyst greatly improved performance. The final OS formulation contained 17% erythorbic acid, 25% DEAE, and 0.5% MnCl2. In MEG solutions at 20 and 50 °C, erythorbic acid was converted into erythorbate with high efficiency. When dosed to give 200 ppm erythorbate in solution, it successfully lowered the oxygen concentration from 1000 to 10 ppb in less than 30 minutes. The performance was also acceptable in lean MEG with small concentrations of an imidazoline-based corrosion inhibitor (2, 7).

Table (5): Effect of Sulphite dose on the feed water quality

No.	Water parameters	Unit	Sulphite Conc. (mg/l)											
			0.5	**1.0**	**2.0**	**4.0**	**6.0**	**8.0**	**12.0**	**15.0**	**Avg.**	**Min.**	**Max.**	**Sd.**
01	DO	mg/l	0.6	0.3	0.2	0.1	0.03	0.01	0.001	0.001	0.159	0.001	0.600	0.196

Sd.: Standard Deviation.

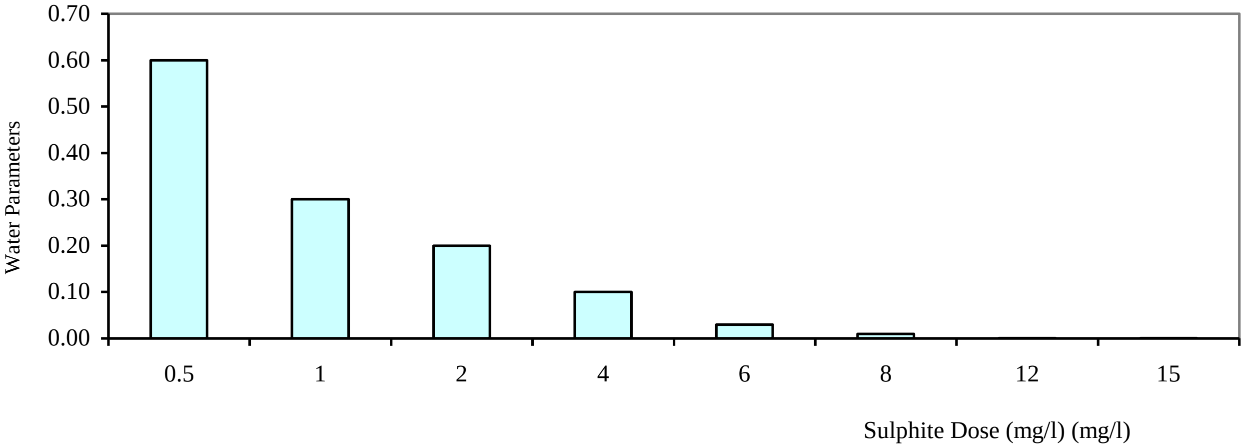


Fig. (6): Effect of Sulphite dose on the feed water quality

Tannin:

In the present study, the Tannin certain doses used in the feed water pre-treatment for boiler and the evaluation of the efficiency was investigated as shown in Table (6) and Fig. (7).

Dissolved oxygen (DO) values revealed that as Tannin doses increased, the treated water became less DO-rich and had no corrosive potential or likelihood, as shown in Table (6) and Fig. (7).

Table (6): Effect of Tannin dose on the feed water quality

No.	Water parameters	Unit	Tannin Conc. (mg/l)											
			0.5	1.0	2.0	4.0	6.0	8.0	12.0	15.0	Avg.	Min.	Max.	Sd.
01	DO	mg/l	0.3	0.1	0.01	0.001	0.001	0.001	0.001	0.001	0.074	0.001	0.300	0.099

Sd.: Standard Deviation.

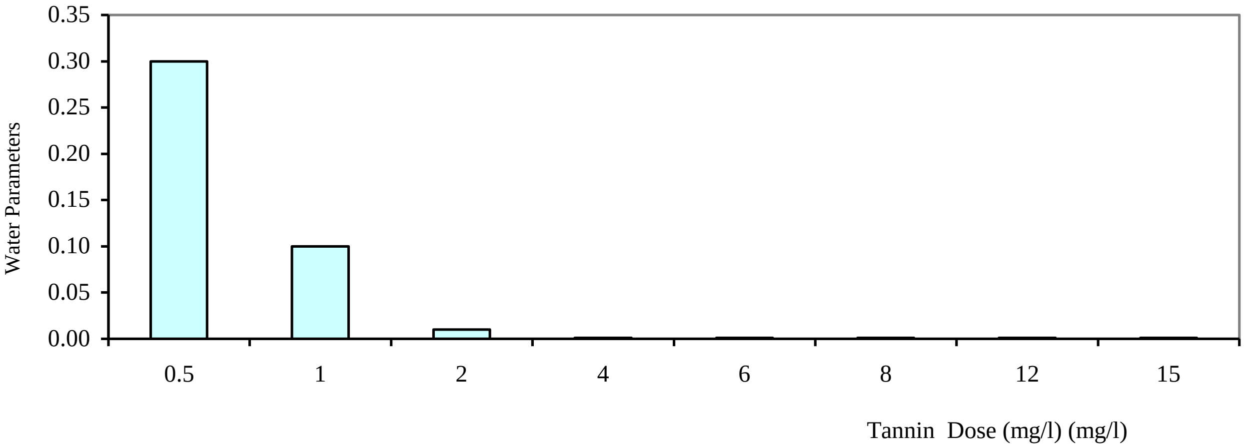


Fig. (7): Effect of Tannin dose on the feed water quality

DEHA:

In the present study, the DEHA certain doses used in the feed water pre-treatment for boiler and the evaluation of the efficiency was investigated as shown in Table (7) and Fig. (8).

The dissolved oxygen (DO) values demonstrated that when DEHA doses increased, the treated water became less dissolved oxygen (DO) and had no corrosive potential or likelihood, as shown in Table (7) and Fig. (8).

Previous studies have demonstrated that formic and glycolic acids may also scavenge oxygen from aqueous solutions through complex radical mechanisms that are similar to those of erythorbic acid. Therefore, it is necessary to research the possibility of using these typical thermal degradation products produced by the regeneration of monoethylene glycol (MEG). By swapping these organic acids for readily available oxygen scavengers like sulfites, the toxicity and subsequent environmental impact of oil and gas products may be reduced. These organic acids have the capacity to reduce chemical inventories, increase project cost efficiency, and be inexpensive. At low concentrations, they are also fast oxygen scavengers (2, 4).

Using manganese (II) ions as a catalyst and formic and glycolic acids as oxygen scavengers after the MEG regeneration process was validated by the experimental results. In salty old lean MEG solutions under alkaline circumstances, diethylhydroxylamine (DEHA), one of the commercial aqueous industrial oxygen scavengers evaluated, was a highly rapid oxygen scavenger (5, 8).

The bulk of the research we reviewed supported the good hydrogen generation capabilities of formic and glycolic acids in aqueous solutions. To far, little research has been done on their capacity to scavenge oxygen in old, salty lean MEG solutions, particularly in the context of processing oil and natural gas. In earlier investigations, the effects of pH on newly made, aged, and thermally damaged lean MEG solutions, as well as the efficiency of erythorbic acid as an oxygen scavenger, were both investigated. However, for this type of oxygen scavenger to be active, there must be an initiator and specific conditions. Diethylethanolamine should first be used to neutralise erythorbic acid before it can be converted into erythorbate. After the solution has been neutralised, 20 ppm of manganese (II) ions are added to begin the radical reaction (9, 24).

The oxygen level is then reduced to under 20 ppb as a result of a series of internal reactions that produce hydrogen ions. The dissolved oxygen (DO) content inside any given processing unit and pipeline must not be more than 20 ppb in order to prevent corrosion and solution degradation.

Table (7): Effect of Sulphite dose on the feed water quality

No.	**Water parameters**	**Unit**	**DEHA Conc. (mg/l)**											
			0.5	**1.0**	**2.0**	**4.0**	**6.0**	**8.0**	**12.0**	**15.0**	**Avg.**	**Min.**	**Max.**	**Sd.**
02	DO	mg/l	0.2	0.01	0.01	0.001	0.001	0.001	0.001	0.001	0.004	0.001	0.010	0.004

Sd.: Standard Deviation.

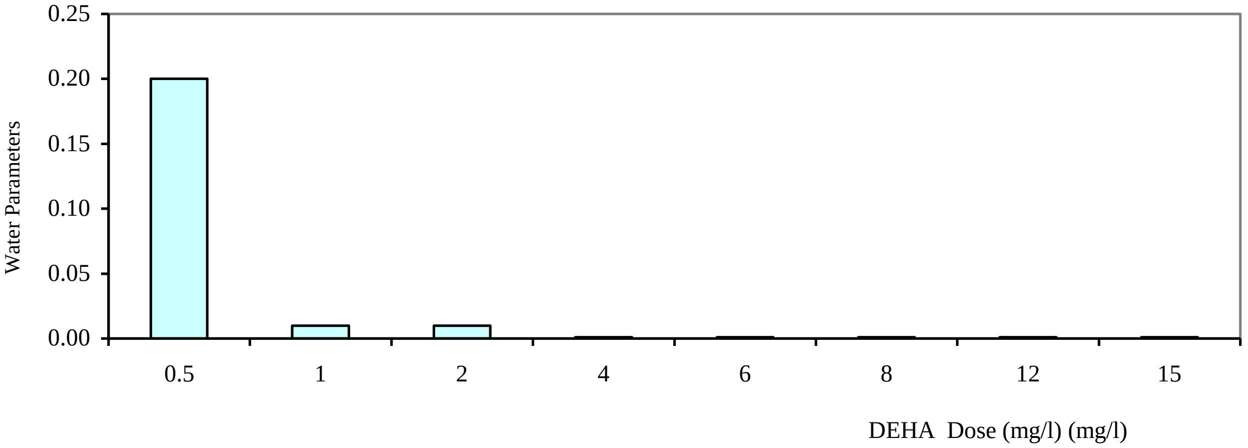


Fig. (8): Effect of DEHA dose on the feed water quality

Carbohydrazide:

As demonstrated in Table (8) and Fig. (9), the effectiveness of the Carbohydrazide at various doses employed in the boiler's feed water pre-treatment was examined in the current study.

The values of dissolved oxygen (DO) show that as carbohydrazide doses were increased, the treated water became increasingly empty of DO and had no potential for or possibility of becoming corrosive. This is shown in Table (8) and Fig. (9).

In addition to offering good protection against oxygen corrosion, carbohydrazide also provides excellent feed water and boiler system passivation. It is used to scavenge oxygen from the air and passivate metal surfaces. a straight replacement for hydrazine in any boiler without the associated handling and safety issues. The boiler system receives little to no ammonia and no dissolved solids from it because it is based on volatile chemistry. It can be used in boilers with any pressure up to 220 bar and injected into feed waters. High-performance carbohydrazide-based organic oxygen scavengers that passivate boiler systems and feed water. They offer excellent defence against oxygen corrosion (11, 25).

Carbohydrazide cannot be used on boilers that produce steam that will come into contact with food or products connected to food. In the realm of water treatment, carbohydrazide can be utilised as an oxygen scavenger for boiler water. It is the most advanced material in the world for deoxidizing boiler water. It has a substantially greater deoxidation efficiency, a higher melting point, and lower toxicity when compared to the materials currently in use. It is the ideal product for preserving safety and the environment. As an oxygen scavenger for boilers, the carbohydrazide can be dissolved in water or used in an aqueous solution. Given that 1 mol of O2 contains 0.5 mol of carbohydrazide, an appropriate excess is used. The temperature range that applies is 87.8-176.7 °C. The moment after thermal deaeration to use carbohydrazide (13, 25)

Table (8): Effect of Sulphite dose on the feed water quality

No.	**Water parameters**	**Unit**	**Sulphite Conc. (mg/l)**											
			0.5	**1.0**	**2.0**	**4.0**	**6.0**	**8.0**	**12.0**	**15.0**	**Avg.**	**Min.**	**Max.**	**Sd.**
02	DO	mg/l	0.6	0.3	0.2	0.1	0.03	0.01	0.001	0.001	0.2	0.0	0.6	0.2

Sd.: Standard Deviation.

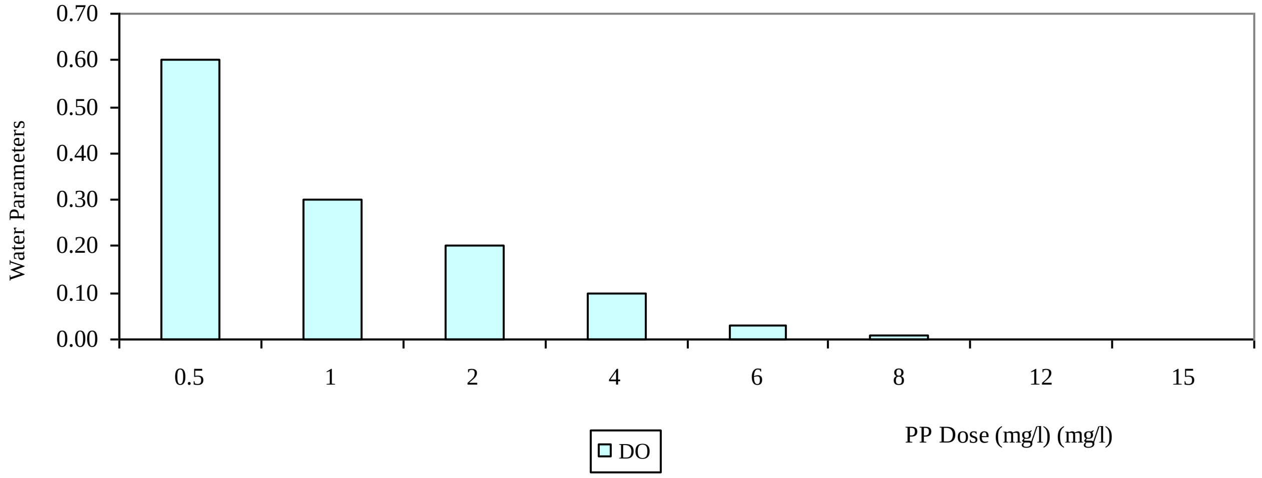


Fig. (9): Effect of Sulphite dose on the feed water quality

Conclusion:

The present study summarized the following points of conclusions;

- The findings suggested that carbohydrazide is a suitable and effective replacement for hydrazine in high-pressure boilers, provided that the feedwater's residual hydrazine concentration is kept between 30 and 40 g kg-1 (hydrazine is a byproduct of carbohydrazide's breakdown).
- Chemicals, such as natural gas hydrate inhibitors, have been injected into the natural gas processing loops, and this has been successful in reducing a number of negative operating concerns related to wet gas pipelines. Pipeline corrosion and clogging are two such issues that could have an impact on the operation's overall economics. However, these substances might change the chemistry of MEG and raise the capital expenditures needed for separation and purification.
- A lot of research has been done over the years on creating oxygen scavenging systems for applications like food preservation. The key technologies utilised in the aforementioned field are highlighted in this review. Iron, palladium, and oxygen scavengers based on unsaturated hydrocarbons are among the systems with high oxygen scavenging rates. Nanoiron can be employed in environments with or without moisture, and it can reduce oxygen from 20.95 vol% to 9.45 vol% or scavenge up to 60 cm^3 of O_2 per day per gramme.
- Sulfite and erythorbate react with oxygen more quickly than their acid conjugates. Erythorbic acid and sulphite were found to have pKa values of 5.1 and 9.4, respectively, in 90% MEG. When the pH is 4 or higher before administering the O_2, the alkalinity in the new O_2 formulation is adequate to maintain erythorbate in unbuffered solutions. The reaction rate for the O_2 formulation as given was unsatisfactory at pH 5.5 but acceptable at pH 7.7 in MEG buffered with acetate/acetic acid.
- Due to their notable advantages, which have already been mentioned, antiscalants, especially environmentally friendly ones, have a wide range of potential applications in the control of RO membrane scaling. In addition, novel, high-performance antiscalants can be designed and manufactured using known structure-activity relationships, and remarkable advancements will be made through efforts to optimise antiscalant applications in real-world settings. These successes may favour the extensive

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