University of Thi -Qar Journal for Engineering Sciences
http://www.doi.org/10.31663/tqujes.12.2.453(2022)
Vol 12.2( December 2022)
ISSN :2664- 5572 ( online)
ISSN:2664-5564 (print)
Available at http://jeng.utq.edu.iq
utjeng@ utq.edu.iq

# EFFECT OF CHEMICAL OXIDES COMPOUNDS IN RAW SEWAGE WATER ON CONCRETE STRENGTH

**Abdulameer Qasim Hasan [†], Saja M Naeem [‡], Hayder K. Aljamee [‡]**
[†] Department of Environmental and pollution engineering, Southern Technical University, Basrah-Iraq, a.almubarak@stu.edu.iq.
[‡] Department of Environmental and pollution engineering, Southern Technical University, Basrah-Iraq, saja.m.naeem@stu.edu.iq.
[‡] Ministry of Oil, Basrah-Iraq, enghaider987@gmail.com.

## Abstract

Wastewater affects concrete structures, causing corrosion and disintegration of concrete, and then corrosion of iron inside concrete due to the presence of salts and chemicals in wastewater. It causes a lack of cohesion between it and the cement paste, and the concrete may crack and collapse. In addition, the presence of salts such as sulfates, chlorides, and sometimes carbonates has adverse effects on concrete. A number of cubes were taken and placed in a basin containing pure water for testing. A number of cubes were placed in a basin containing sewage water, and a number of cubes were placed in basins containing these solutions $AL_2O_3$ (Aluminium oxide), $SiO_2$ (Silicon dioxide), $TiO_2$ (Titanium dioxide), $Fe_2O_3$ (Iron oxide), $K_2O$ (potassium oxide), MgO (Magnesium oxide), $SO_3$ (Sulfur trioxide), CaO (Calcium oxide), MnO (Manganese oxide), $P_2O_5$ (Phosphorus pentoxide)). and after checking the results in 7, 28, 56, and 90 days. The result of the test was that it appears the elements that increase the compressive strength of concrete are ($AL_2O_3$, $SiO_2$, $Fe_2O_3$, and $TiO_2$) with a rate of 30% at 28 days, 39% at 56 days, and 43% at 90 days. At the same time, the elements that reduce the compressive strength of concrete are ($K_2O$, MgO, $SO_3$, $P_2O_5$, MnO, CaO, and BOD) with a rate of 18% at 28 days, 24% at 56 days, and 29% at 90 days.

***Keywords:*** heavy metals, concrete material, sewage, water tank.

## 1. Introduction

Corrosion is defined as the deterioration of a substance or its properties as a result of its interaction with external or internal influences, or it is the damage resulting from the interaction of two or more substances or their components in the presence of moisture or wet medium.

Corrosion occurs in facilities very slowly and quietly, but the losses it causes are unimaginable, including physical, economic, and health-related losses that directly affect human health and the environment around him. Industrial facilities and service buildings such as schools, hospitals, power stations and power transmission poles, bridges, roads, ports, and airports are negatively affected by corrosion in their parts, which leads to shortened lives, reducing their service life and operational efficiency, which increases the cost of their maintenance and operation.

Water distribution, pumping stations, and water storage are subject to erosion, whether inside the transmission and distribution lines and their accessories, or from outside the lines and visible parts that are exposed to various environmental and climatic changes **[1].**

Wastewater affects concrete structures in two ways: first, the salts and chemicals in the sewage water cause the concrete to erode and disintegrate; second, the iron within the concrete also erodes. It results in a lack of cohesiveness between it and the cement paste, possibly leading to concrete cracking and fragmentation. Additionally, salts like sulfates, chlorides, and occasionally carbonates have a negative impact on concrete **[2].**

Cement is a soft bonding hardened material, thus having cohesive and adhesive properties in the presence of water, which makes it able to bind the components of concrete to each other. The most important use of cement is mortar and concrete, where it binds synthetic or natural materials to form strong building materials that are resistant to normal environmental influences **[1][3].**

Its properties, uses and advantages differ according to the materials used during its manufacture; Sulfate-resistant cement is used in areas where sudden changes in temperature and large amounts of rain occur. Portland cement is recommended for places such as canals, retaining walls, siphons, pumping stations and water drainage. It has great resistance to the negative effects of chemical compounds and natural changes **[4].** Cement is a mixture of natural elements such as limestone, clay and sand. It is often used to permanently close the penetration of water in a specific area. when mixing it with water, sand and gravel, we get concrete and when mixing it with water and sand, we get a cement plaster, and when mixing it with water, lime and sand, we get clay.

One of the main worries is how pollution particles damage water. Water that has been released from industrial, agricultural, and home waste is considered wastewater. Usually, wastewater contains a wide variety of pollutants. Inorganic particles like sand, gravel, metal, and ceramic particles; pathogenic substances like bacteria, viruses, and parasitic worms; and nitrogen (organic or inorganic) in the forms of urea, ammonia, nitrites, and nitrates, phosphorus, proteins, drugs, sea salt, cyanides, cyanides Tello, and Tello sulfates are the main pollutants in wastewater, Gases such as carbon dioxide, methane, and hydrogen sulfide are emulsifiers used in paints, adhesives, hair colors, and oil [5].

The main objective of this study is to investigate the practical facts of corrosion in concrete as a result of sewage water as well as to study the effects of oxides of compounds present in sewage water (each oxide individually) on concrete by chemically examining sewage water and determining the compressive strength of concrete cubes immersed in water, sewage, and oxides.

## 2. Methodology

In this research, (156) cubes were used, each cube with (15 * 15 * 15 cm) dimension, mixing ratio (1 :2:4) (cement, sand, gravel) Picture 1. After 24 hours the cubs are dry and a number of cubes are placed in a basin containing pure water for testing, and an each (12) cubes are placed in a basin containing sewage water, and in basins containing these solutions (AL2O3, SiO2, TiO2,Fe2O3, K2O, MgO, SO3, CaO, MnO, P2O5) by dissolved 10% weight of these component in 1 liter of distilled water with continuous mixing - and after 7 days, 28 days, 56 days, then in 90 days Picture 2. The results are examined so that the result s of the examination appear in these days and compared. Sewage samples were taken from Hamdan sewage station in Basra Governorate Picture 3, test were carried out to show the Temperature(C°), pH, EC (µs/cm), BOD (mg/l), COD (mg/l), TSS (mg/l), TDS (mg/l), Cl (mg/l), NH3 (mg/l), NO3 (mg/l), PO4 (mg/l), Oil &Grease (mg/l) were examined as shown in table 1.

**Table 1** Sewage Test

| Temperature(C°) | 24C° |
|---|---|
| pH | 7.85 |
| EC (µs/cm) | 6221 |
| BOD (mg/l) | 310 |
| COD (mg/l) | 724 |
| TSS (mg/l) | 307 |
| TDS (mg/l) | 4851 |
| Cl (mg/l) | 1438 |
| $NH_3$ (mg/l) | 32 |
| $NO_3$ (mg/l) | 7.4 |
| $PO_4$(mg/l) | 8.7 |
| Oil &Grease(mg/l) | 169 |

Also, heavy metals are examined in sewage samples, as shown in table 2.

**Table 2** Test of the Heavy Metal Oxides in sewage sample.

| Oxides | weight percent wt. % |
|---|---|
| $AL_2O_3$ | 39.1 |
| $SiO_2$ | 30.2 |
| $Fe_2O_3$ | 25.8 |
| $K_2O$ | 1.4 |
| $TiO_2$ | 1.4 |
| MgO | 0.6 |
| $SO_3$ | 0.6 |
| $P_2O_5$ | 0.3 |
| MnO | 0.3 |
| CaO | 0.2 |
| Others | 0.09≤ |

**Picture 1** Hand mixing

**Picture 2** Cubes after Pouring

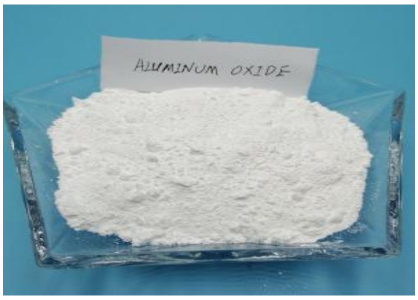
**Picture 3** Cubes test

## 3. Oxides properties

### *3.1.* Aluminum Oxide $AL_2O_3$

It is found commercially as a white powder, odorless and non-toxic, very hard material that has a high resistance, resistant to reactions with acids and bases at high temperatures, and can appear in different colors: red or sapphire yellow, pink, sapphire blue, purple, green, gray, and even colorless. Its density is 3.96

g/cm3, molecular weight (molar mass) is 101.96 g/mol, and it is insoluble in water [6] Picture 4.




**Picture 4** Aluminum Oxide

### *3.2.* Silicon Dioxide *$SiO_2$*
Amorphous silica is a colorless to gray solid with a gram molecular weight of 60.084 g/mol and a density of 2.17-2.32 g/cm3. It is soluble in alkali, especially if finely divided, and resists attack by chlorine, $Cl_2$, $Br_2$, hydrogen $H_2$, and most acids at room temperature or slightly above **[7].**

### *3.3.* Iron Trioxide *$Fe_2O_3$*
Molar Mass 159.69g/mol, Density 5.242g/cm3 **[8].** Picture 5

**Picture 5** Iron Trioxide

### *3.4.* Potassium Oxide *$K_2O$*
Potassium oxide is a yellow tetrahedral crystal without a characteristic odor, the molecular compound has a mass of 94.2 g/mol , Density of 2.13 g/mL at 24 °C, The compound is heat resistant and soluble in ethanol and other. $K_2O$ it crystallizes in the antifluorite structure, It is a basic oxide and reacts violently with water to produce caustic potassium hydroxide. It's full and absorbs water from the atmosphere, and this powerful reaction starts Potassium oxide is reversibly oxidized to potassium peroxide at 350 ° C **[9].**

### *3.5.* Titanium Dioxide *$TiO_2$*
Pure titanium is a dark gray, shiny metallic powder, density is 4.6 g/cm2, brittle metal at low temperature, and easy to break at room temperature, but becomes malleable at high temperatures. Titanium has important physical properties; Small amounts of oxygen and nitrogen can make a more powerful material, its resistant to reaction with acids such as: chlorine, and corrosive agents; A corrosive agent is a substance that tends to react vigorously with certain substances. Titanium becomes more reactive at high temperatures, and it catches fire when heated in the presence of oxygen [10].

**Picture 6** Titanium Dioxide

### *3.6.* Magnesium Oxide *MgO*
The molar mass 40.3044 g/mol, density 3.58g/cm$^3$, odorless white powder, slightly soluble in water, insoluble in alcohol. It dissolves in acids and ammonia. reacts with gastric hydrochloric acid to form magnesium chloride **[11]** Picture 7.

**Picture 7** Magnesium Oxide

### *3.7.* Sulfur Trioxide *$SO_3$*
Colorless to white crystalline solid, Odorless, Complexity 61.8, Solubility Soluble in water, Sulfur trioxide compound reacts with water producing sulfuric acid When immersing the cubes in water containing $SO_3$ [12].

$$SO3 + H2O \rightarrow H2SO4 \quad (1)$$

### *3.8.* Phosphorous Pent oxide *$P_2O_5$*
The molar mass is 283.886g/mol. It is a white powder, very deliquescent, odorless, and 2.39 g/cm$^3$ in density. Solubility in water, exothermic hydrolysis **[13].** Picture 8

**Picture 8** Phosphorous Pent oxide

### *3.9.* Quaternary manganese Oxide *MnO*

The molar mass is 86.94g/mol. It is a black steel. The density is 5.03g/cm$^3$. Undissolved in water, it reacts with hydrochloric acid to release chlorine gas to form manganese (II) chloride **[14]** Picture 9.

**Picture 9** Quaternary manganese Oxide

### **3.10.** Calcium oxide CaO

The molar mass is 56.08g/mol, the appearance is white powder with a density of 3.37g/cm$^3$, It reacts upon contact with water (hydrolysis reaction) in an exothermic manner, forming calcium hydroxide (slaked lime) [15] Picture 10.

**Picture 10** Calcium oxide

## 4. Results and discussions

In this study, the results of cubes flooded in sewage, RO water, and solutions (AL2O3, SiO2, Fe2O3, K2O, $TiO_2$, MgO, SO3, P2O5, MnO, CaO, BOD) were compared to the results of normal concrete. The following results were obtained:

### 4.1 Cubes in RO water

When the cubes were immersed in RO water, it was found that the compressive strength with a lifetime of (7,28,56,90) days was normal compared to the normal results. The results of cubes immersed in RO water were adopted in comparison with cubes immersed in other water and sewage water, as shown in figures 1 and 2.

### 4.2 Cubes in $AL_2O_3$ water

When immersing the cubes in water containing $AL_2O_3$, it was found that the cubes that have been immersed for 7 days are normal. Cubes that were immersed for 28 days increased by 15.7%, cubes that were immersed for 56 days increased by 16%, and cubes that were immersed for 90 days increased by 19%. It is conclude that the compound $AL_2O_3$ increases compressive strength as shown in figure 1, but reduces the time of concrete installation.

### 4.3 Cubes in $SiO_2$ water

When the cubes were immersed in water containing $SiO_2$, it was found that: the cubes that were immersed for 7 days were normal; cubes that were immersed for 28 days increased by 10.6%; cubes that were immersed for 56 days increased by 11.4%; and cubes that were submerged for 90 days decreased by 11%. It is concluded that the compound $SiO_2$ increases the compressive strength of concrete, as shown in figure 1.

### 1. 4.4 Cubes in $Fe_2O_3$ water

It was found that cubes that were immersed for 7 days were normal, cubes that were immersed for 28 days increased by 13.7%, cubes that were immersed for 56 days increased by 21.5%, and cubes that were submerged for 90 days increased by 24.8%. it is concluded that the compound $Fe_2O_3$ reduces the strength and pressure on concrete, as shown in figure 1.

### 2. 4.5 Cubes in $K_2O$ water

When immersing the cubes in water containing $K_2O$ , it was found that: the cubes that were immersed for 7 days the ratio was 21.7%, the cubes that were immersed for 28 days decreased by 18%, the cubes that were immersed for 56 days increased by 25%, and the cubes that had been immersed for 90 days increased by 31%. We conclude that the compound $K_2O$ reduces the compressive strength and causes cracks and cavities in concrete as shown in figure 2.

### 3. 4.6. Cubes in $TiO_2$ water

4. When immersing the cubes in water containing TiO2 [10], the cubes that have been immersed for 7 days are 2.1% normal. Cubes immersed for 28 days decreased by 1.6%, those immersed for 56 days decreased by 0%, and those immersed for 90 days increased by 2.1%. We conclude that the compound TiO2 cement moisturizes as shown in figure 1.

### 5. 4.7 Cubes in MgO water

When immersing the cubes in water containing MgO, it was found that the cubes that had been immersed for 7 days decreased by 18.6%, those immersed for 28 days increased by 31.1%, those immersed for 56 days increased by 37.4%, and those immersed for 90 days increased by 43.3%. We conclude that the compound MgO crushes concrete as shown in figure 2.

## 4.8 Cubes in $SO_3$ water

When immersing the cubes in water containing SO3, it was found that: the cubes that have been immersed for 7 days are 23.04% normal, Cubes immersed for 28 days increased 38.3%, Cubes immersed for 56 days decreased 29.35%, and Cubes immersed for 90 days decreased 38.4%.We conclude that the compound SO3 reduces the strength of concrete, as shown in figure 2.

### 4.9 Cubes in $P_2O_5$ water

When immersing the cubes in water containing $P_2O_5$, it was found that: the cubes that have been immersed for 7 days are 31.3% normal, Cubes immersed for 28 days increased 38.3%, Cubes that have been immersed for 56 days have reduced 35.1%,Cubes immersed for 90 days increased 47.07%,We conclude that the compound $P_2O_5$ reduces compression as shown in figure 2. .

### 4.10 Cubes in MnO water

The cubes immersed for 28 days increased by 14.5%, the cubes immersed for 56 days decreased by 12.2%, and the cubes immersed for 90 days decreased by 21.5%, indicating that MnO causes concrete instability, as shown in figure 2.

.

### 4.11 Cubes in CaO water

The cubes that were immersed for 28 days increased by 7.7%, the cubes that were immersed for 56 days decreased by 5.16%, and the cubes that were immersed for a period of 56 days Submerge for 90 days decreased by 13.5%. We conclude that the compound CaO causes instability of concrete as shown in figure 2.

### 4. 12. Cubes in BOD water

When cubes were immersed in water containing BOD, cubes that were immersed for 7 days found that the percentage was 2.12%, cubes that were immersed for 28 days increased by 3.38%, cubes that were immersed for 56 days increased by 4.83%, and cubes that were immersed for 56 days increased by 4.83%. As shown in figure 2, concrete that was immersed for 90 days increased by 13.5%. We conclude that the BOD compound reduces tensile and compressive strength and causes cracks and cavities in concrete as shown in figure 2.

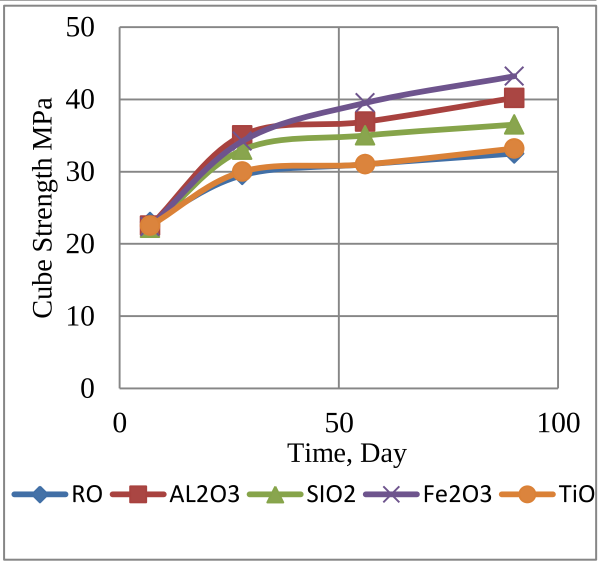



**Fig. 1** Elements that increase the compressive strength of concrete

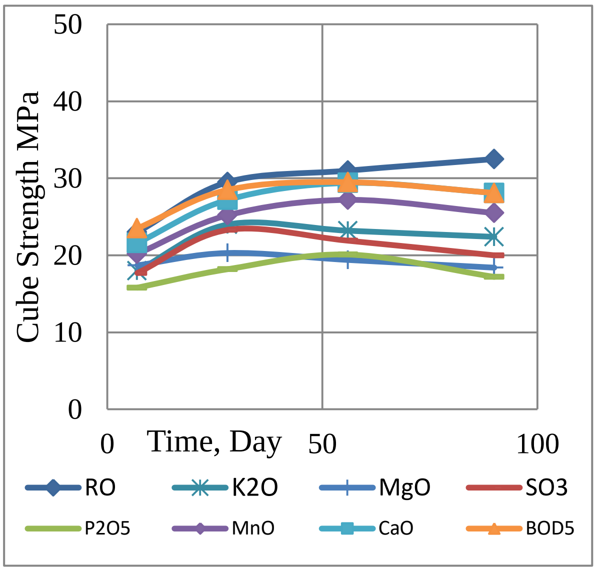



**Fig. 2** Elements that reduce the compressive strength of concrete

**Conclusion**

Through the above in the result and figures 1 and 2, a summary can be made about the effect of the elements present in the sewage water. At 28 days (the increase in AL2O3 element is 35 MPa, and the lowest level was in TiO3 element is 30 MPa), at 56 days (the increase in Fe2O3 element is 39.5 MPa, and the lowest level was in TiO3 element is 31 MPa), and at 90 days (the increase in Fe2O3 element is 43.2 MPa, and the lowest level was in TiO2 element is 33.2 MPa).At 28 days (P2O5 was the lowest at 18.2 MPa and the highest in the element BOD5, which was 28.5 MPa) and 56 days (it decreased in the MgO element, which was 19.4 MPa, and the highest level was in the element CaO, which was 28.1 MPa).

## Reference


[1] Hilal, Nahla Naji. "Effect of Chloride Salt on Reinforced Concrete Structures." *Anbar Journal of Engineering* Sciences,2012.

[2] PCA, "Types and causes of concrete deterioration," *Portl. Cem. Assoc. - Concr. Inf.*,2002, 1.

[3] Y. Zamrodah, Cement and Concrete Chemistry. 2016, 15,2.

[4] S. Malasri and S. Maldonado, "Concrete mix designer," *Am. Concr. Institute, ACI Spec. Publ.*, 1988, SP-111, 33,

[5] H. Esmaeili and R. Foroutan, "Types of Sewages and Reviews of Wastes Biological Filtration, 2015, 2277.

[6] K. N. Yathish Narayana Rao and K. Mohamed Kaleemulla, "Mechanical characterization of pure aluminium oxide (AL2O3)," *Int. J. Mech. Prod. Eng. Res. Dev.*,2018, 8, 2, 355,.

[7] V. G. Il'Ves, M. G. Zuev, and S. Y. Sokovnin, "Properties of Silicon Dioxide Amorphous Nanopowder Produced by Pulsed Electron Beam Evaporation," *J. Nanotechnol.*, 2015.

[8] M. R. Joya, J. Barón-Jaimez, and J. Barba-Ortega, "Preparation and characterization of Fe2O3 nanoparticles," *J. Phys. Conf. Ser.*, 2013, 466, 1.

[9] S. H. Mohamad and M. A. A. M. Nor, "Effect of K2O contents on the releasing of nutrient ions from phosphate glass system," *Key Eng. Mater.*, 2016, 723 KEM, 545,.

[10] H. Kwon and S. Kang, "Carbothermal reduction of titanium monoxide (TiO)," *J. Ceram. Soc. Japan*,2008, 116, 1358, 1154,

[11] S. R. and S. S. Z. S.Lidvin Daisy, A.Christy Catherine Mary, Kasthuri Devi, , S SanthanaPrabha, "Magnesium oxide nanoparticles-Synthesis and Charecterisation," *Int. J. nano Corros. Sci. Eng.*, 2015, 2, 5, 65.

[12] ATSDR, "Sulfur trioxide (SO3) and Sulfuric acid," *Agency Toxic Subst. Dis. Regist.*, 1999, June, 2.

[13] H. Eshghi and P. Shafieyoon, "P2O5 / SiO2 as a mild and efficient reagent for acylation of alcohols, phenols and amines under solvent-free conditions," *J. Chem. Res.*,2004, 12, 802, .

[14] B. K. Pandey, A. K. Shahi, and R. Gopal, "Optical and Electrical Transport Properties of MnO Nanoparticles," *Mater. Focus*, 2013, 2, 3, 221

[15] A. Lesbani, S. O. Ceria Sitompul, R. Mohadi, and N. Hidayati, "Characterization and Utilization of Calcium Oxide (CaO) Thermally Decomposed from Fish Bones as a Catalyst in the Production of Biodiesel from Waste Cooking Oil," *Makara J. Technol.*, 2016, 20, 3, 121