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A number of corrosion issues with regard to wastewater treatment plants

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ABSTRACT

In order to protect the environment and public health of the communities, every city around the world, including Turkey, faces the problem of dealing with wastewater, and this is primarily dealt with by means of the services provided by the wastewater treatment plants. Wastewater is usually removed by the wastewater treatment system and sometimes by the non-sublimation process. The wastewater treatment plants can be carefully constructed and designed to prevent plants corrosion problems. It is very important to achieve high efficiency for the wastewater treatment centres. To this aim, construction of Supervisory Control and Data Acquisition (SCADA) system would help the treatment plants to be more efficient and work in a more economic way. The SCADA system is a combination of control panel and power of command components. This system entails water management and the efficiency of all systems as well as the corrosion control. When the wastewater transfer centres are examined, it can be easily observed that there are many corrosion effects in these centres. To deal with this aspect, in this study we show how the biological mass kinetic values affect the corrosion problems in wastewater treatment systems.

Keywords: Wastewater transfer centre; Corrosion; SCADA system; Wastewater treatment system; Prevention from corrosion

1. Introduction

The wastewater and water treatment plants are taken into consideration not only in relation to environment and the city life, but also to the use of water in agricultural area [1]. The newly projected wastewater systems supply better and cheaper solutions in various life areas. The corrosion of many materials such as metals, alloys and composites is an undesirable natural process which limits the human life standards [2,3]. Canalization systems consist of channels and pipelines with open water surface, under pressure and unpressured atmosphere with canals of different diameter. The slope of the canals changes mostly between 0.5% and 1.5%. Sometimes, the slope of channels may decrease to 0.5%–0.1%. The wastewater flow rate is generally of 1 m/s and the temperature changes between 8°C and 18°C in winter and 10°C–25°C in summer. The condition of the working channel systems under pressure is mostly an anaerobic process. Due to this reason, sulphates are formed and degradable organic substances disappear. Along the canalization pipeline, depending on the time of wastewater running through the canal, various changes in the composition can be observed. In this work, a number of changes in wastewater, such as pH, biological oxygen demand (BOD), chemical oxygen demand (COD), total nitrogen (TN) and NO_3 organic substances, are examined [4]. When examining the wastewater and the treatment system collectors, the treatment gases as a volumetric percentage are of the following amounts: 60%–70% CH_4, 26%–36% CO_2, 1%–10% N_2, 0%–1.7% O_2, 0%–1% H_2 and 0%–2% H_2S. Treatment gases are normally lighter than air and flammable. In addition, if the volume percentage is between 5% and 19% (treatment gases and air mixture); these gases are dangerous and explosive. The wastewater from canals may mix with rain water due to some tanker accidents, as it may also have benzene, propane, butane, acetone, acids and other chemical substances. Wastewater gases at the wastewater elevation centre generally are in a collecting reservoir. When building a pump station, wastewater spaces and other places should be

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certainly distinguished one from another. Wastewater gases are due to the wastewater leaky compression packing, and the smuggled water is picked up in a small time period. If the smuggled water does not pump outside, it is picked up in some places due to the building floor gradient, which is not enough. Sometimes we encounter decay water. As a result of this decay, H_2S gas changes to H_2SO_4 at top surfaces and causes the corrosion in the canal. At the treatment plant, as a result of this decay and of H_2S, corrosion occurs depending on the treatment of gas amount. In general, at elevation centres and pump stations, the substances from wastewater represent the source of their corrosion. Air at picked store is taken directly outside of wastewater elevation centres, and corrosion occurs much more than in other places. Due to this reason, the picked store waiting time can be a small time period. It is carefully observed that the wastewater does not begin the decay process in this area. In other words, all the wastewater can be conducted in the system. The topic is important to prevent corrosion process in the wastewater canals and at the wastewater treatment plants.

2. Results and discussion

2.1. Corrosion process in wastewater canals and at treatment plants

The changes in nitrogen compounds are observed at high nitrate concentration level in canalization systems. Nitrates run against denitrification under biologic curtain sheet in canal treatment. Nitrification process is possible due to dissolved oxygen. Eymontt and Romaniuk [5] show two main environmental problems and their solutions. One of them is the treatment of animal farm wastes and wastewater of the food industry. The other is the treatment of domestic wastes from separately located farms. A few projects began to be implemented by the EUROTECHNOLOGY within the international EUREKA program. The practical application of methane fermentation of manure and food industry wastes with the production of biogas, electric energy and compost has been suggested. The main goal of this project is the conversion of organic wastes in a closed ecological circuit without environmental pollution. The regional sewer systems affect subcentral treatment plants. High sewage temperatures bring about new environmental problems, such as odourous and corrosive compounds, and hydrogen sulphide. A new method was developed to avoid local and general nitrate overdosing by an optimum arrangement of the dosing stations. For example, the canalization and wastewater treatment system was redesigned in the late 1970s in Lake Balaton [6]. As a result, nitrification plays a small role in the system. Denitrification consists of nitrates obtained from wastewater [7]. The bacteria activated with oxidized H_2S in canalization system expand H_2SO_4–H_2O mixture on the surface of wastewater. H_2S in aqueous form shows toxic effect on the plant members [8]. Gandhi et al. [9] focus on the flow and pressure distribution in diffuser system of aerobic biological treatment, steam distribution in passive decay heat removal systems, etc. Sulphide ions have two electrons in waste materials in the mixture of wastewater structure. Sulphides expand stench and they affect negatively the health. They also cause the corrosion in concrete collectors and canals with treatment plants. In the case of oxygen gases, there is 0.2–0.5 mg/L in wastewater canals used in gravity law. Substitution of sulphates does not pose hazards [10]. The amount of sulphates in water decreases with bacteria (SBR), carbon, energy source, organic acids, etc. The following chemical reaction occurred in wastewater:

$$8e + SO_4^{2-} + 8H^+ \rightarrow S^{2-} + 4H_2O \quad (1)$$

Sulphates represent an anaerobic process and they resist oxidase process [11]. Anaerobic steps constitute daily changes and atmospheric phenomena, such as rain, snow, etc. SBR converts sulphate ions to N_2S, which is a very simple process. During the reaction, the conversion of S^0 or thiosulphate ($S_2O_3^{2-}$) partially starts.

$$4S^0 + 4H_2O \rightarrow SO_4^{2-} + 3H_2S + 2H^+ \quad (2)$$

This reaction only starts to exist when H_2S [12]. SBR constitutes sediments at low level of organic substrates of active areas.

$$\left.\begin{aligned} S^{2-} + 2H^+ + 0.5O_2 &\rightarrow S^0 + H_2O \\ S^0 + H_2O + 1.5O_2 &\rightarrow SO_4^{2-} + 2H^+ \\ 4NO_3 + N_2S &\rightarrow 4NO_2 + SO_4^{2-} + 2H^+ \end{aligned}\right\} \quad (3)$$

The reduced amount of S was used as a reactive. When the pH = 8, and the temperature occurs at 20°C, the oxidation rate can be calculated by the following Eq. (4):

$$r_s^{-2} = 0.41S_t^{0.39} \cdot S_0^{0.57 \cdot \log S_t} \cdot 24 / 32 \quad (4)$$

where r_s^{-2} is chemical oxidation rate of sulphide (mol × m^{-3} × d^{-1}). S_t is the total sulphide concentration (S_{S-2} + S_{HS} + S_{H_2S}, mol × m^{-3}). The sulphuric compounds (sulphur) are formed with assimilation process by organic and inorganic microorganisms [13]. Sulphur sometimes reaches the canalization system by means of industrial wastewater. However, the basic source of sulphur constitution in canalization system is biologic activity. Sulphur occurs with gravity force used in open flowing canalization system at high temperature, big canal radius, low discharge rate and not enough air conditioner facilities. In pressured systems, when the wastewater stops at static condition for 1–2 h, sulphur starts to form. Sulphate converts to sulphur via anaerobic process. Wastewater reaches to 50% contact with air, which converts to soluble oxygen. Oxygen does not reach from top surface to bottom surface. Chlorine dioxide is used as an important disinfectant over a wide pH range. It kills bacteria and is used in deactivating viruses [14,15]. Some parts of oxygen in air are diffused to wastewater sulphate compounds in contact with oxygen and decompose easily. Anaerobic layer occurs in canal, and up of this layer, anaerobic layer exists in the canal. Oxygen and nutrition substances diffuse to anaerobic layer. Sulphates pass to anaerobic layer. Hydrogen sulphide is of critical importance in the corrosion of canal system and wastewater treatment process. The corrosion obtained at pump station and wastewater treatment plants has the same amount as shown in Fig. 1. There is a continuous interaction

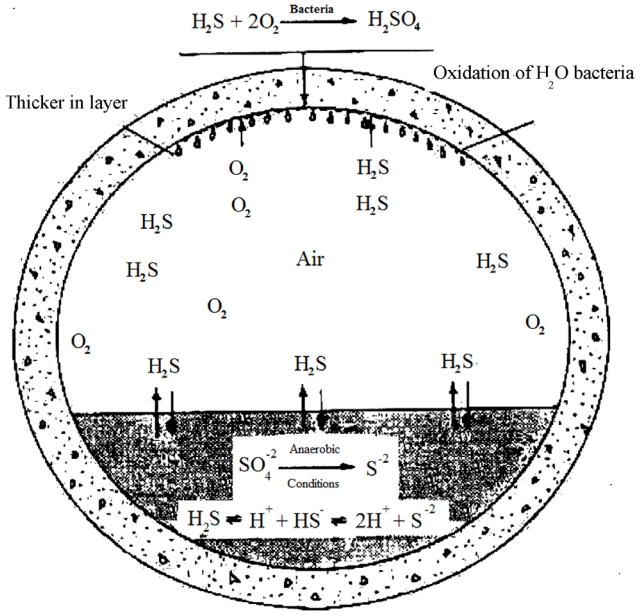

Fig. 1. The corrosion of hydrogen-sulphur forms in canalization system.

between sulphur in wastewater and atmosphere. When the pH value decreases in wastewater, the concentration of hydrogen sulphide in water increases. The corrosion nearer the collector surface by changing of H_2S to gas phase.

Hydrogen sulphide contacts oxygen and is converted to sulphuric acid by means of *Thiobacillus* bacteria.

$$H_2S + 2O_2 \xrightarrow{\text{Thiobacillus}} H_2SO_4 \quad (5)$$

The corrosion occurs outside the pipe in concrete canals. There are many factors that affect the hydrogen sulphide formation, such as pH, oxygen, acid, bases, chlorides, etc. The most efficient method of hydrogen sulphur corrosion is to form prevention of hydrogen sulphur formation. So, oxygen concentration should not be <1 mg/L in the canal system. If the amount of oxygen is less, the oxygen should be given to the system. When the chlorides mix with wastewater, sulphur oxidizes to sulphate in the following reaction (6). The corrosion concrete canal is shown in Fig. 2.

$$HS^- + 4Cl_2 + 4H_2O \rightarrow SO_4^{2-} + 9H^+ + 8Cl^- \quad (6)$$

Important changes in organic substance and electron withdrawing character and elements start in the wastewater canalization discharge system. As a result of the measurements, in winter months, every 1 g O_2 destroys 0.7 g BOD. However, in summer months at 20°C–24°C, 1.4 g BOD is destroyed [16]. In their applications, scientists have used synthetic glucose in wastewater. The results show that destroying organic substance and nitrogen is important for biologic curtain in canal [17]. Gondim-Porto et al. [18] have investigated the bacteria in agricultural soils under Mediterranean climate after urban sludge amendment. Cao and Alaerts [19] have studied a well-mixed indoor recirculating channel which was adapted to investigate aerobic heterotrophic biodegradation

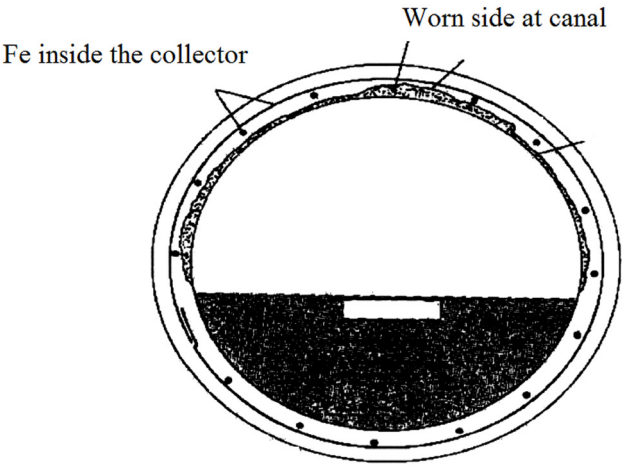

Fig. 2. The corrosion formation in concrete canal.

kinetics and microbial communities in drainage systems with suspended and attached biomass. Average discharge rate is 0.07 ms^{-1} at canal. In addition, biological mass kinetic values are given as:

$$\mu_m = 0.76\,d^{-1}, \quad K_S = 2.5\ mg/L$$

$$\mu_m = 0.52\,d^{-1}, \quad K_S = 2.9\ mg/L$$

In addition, biological mass kinetic values are given as follows: N_2 charging rate is 3.78 kTN/m^2 d was obtained at domestic wastewater. The optimum N_2 disappearing was obtained as 0.77 kTN/m^2 d. In this situation, charging and disappearing of COD rates was found as 22, 27 and 45 g COD/m^2 d. The charging rate was also investigated in decomposed O_2 level. Tandukar et al. [20] have studied the soluble organics, which comprise the high BOD remaining in the effluent from direct physicochemical treatment of strong raw sewage. Srinivasan et al. [21] have constructed wetlands, which are becoming an accepted method for managing water pollution and their number and range of applications. Treatment wetland technology is important to save money. The treatment of wetland supply water quality aims to protect human and environmental health. Akca and Samsunlu [22] have reported that there are around 2,000 small treatment plants in Turkey. However, there is necessary to construct some 10,000 more wastewater treatment plants to solve the wastewater problems in small settlements. Akca and Samsunlu [22] have investigated 96 treatment plants. Aerated biofilter systems would be easily adapted to meet the serious standards that are proposed for sensitive zone.

2.2. Corrosion and its representations

The general building elements of average duty time should be of at least 15 years. This time can be solved by the corrosion problem. The elevation centre is very important, which can be designed successfully with good technique. The microorganisms on the building wall (inside the wastewater and on the wastewater level) easily convert from H_2S to H_2SO_4. This redox reaction causes the corrosion process with

all metals. These types of metals change in concrete material. For instance, H_2S damages the copper metal by forming sulphites [23]. Especially, the bottom of the panels changes completely from copper sulphite powder to black colour. Thin copper wires completely disappear. When the H_2S concentration is over 0.5 ppm, H_2SO_4 corrosion starts on the structure. To prevent this type of corrosion, picked storage walls can be more stabilized. Epoxy resins supported by fibre glass materials should be used in new constructions.

Sometimes, the concrete walls of the passing pipes leak water. In this case, steel pipes inside concrete walls decompose with corrosion particularly at air condition crossing points. A number of pictures of the corrosion of the materials are given in Fig. 3. In all these situations, wetness occurs at wastewater pump stations, where air wetness increases. Before the painting of steel materials at pump station buildings, corrosion-preventing paints should be used. In particular, there are corrosion problems at welded joints, flan cards and connection screws.

2.3. The corrosion prevention method

After the wastewater elevation centre works for some 20 years, the centre's condition should be nearly the same at the beginning despite that the centre's normal corrosive processes would occur at the centre [24]. To reach this result, when establishing the plant, the correct material should be performed by correct technique. The corrosion conditions of wastewater plants and components are different from those in the normal wastewater buildings. It is stronger required to have in the building of the plants good sand, fibre materials, etc. Other corrosion pictures are given in Fig. 4.

Defective and expensive sensors should not be used at the plants. The solution of automation bases is to confide in every stage. We should control all parts of the plant (gate control, supply of electrical energy, sheets, etc.). We do not leave unnoticed a weak point or a problem. Supervisory Control and Data Acquisition (SCADA) is usually used for wastewater treatment, municipal water treatment systems

Fig. 3. (a) The damages of electric ports, (b) mechanical leakage of compression packing, (c) open screws and (d) armature bowl decayed.

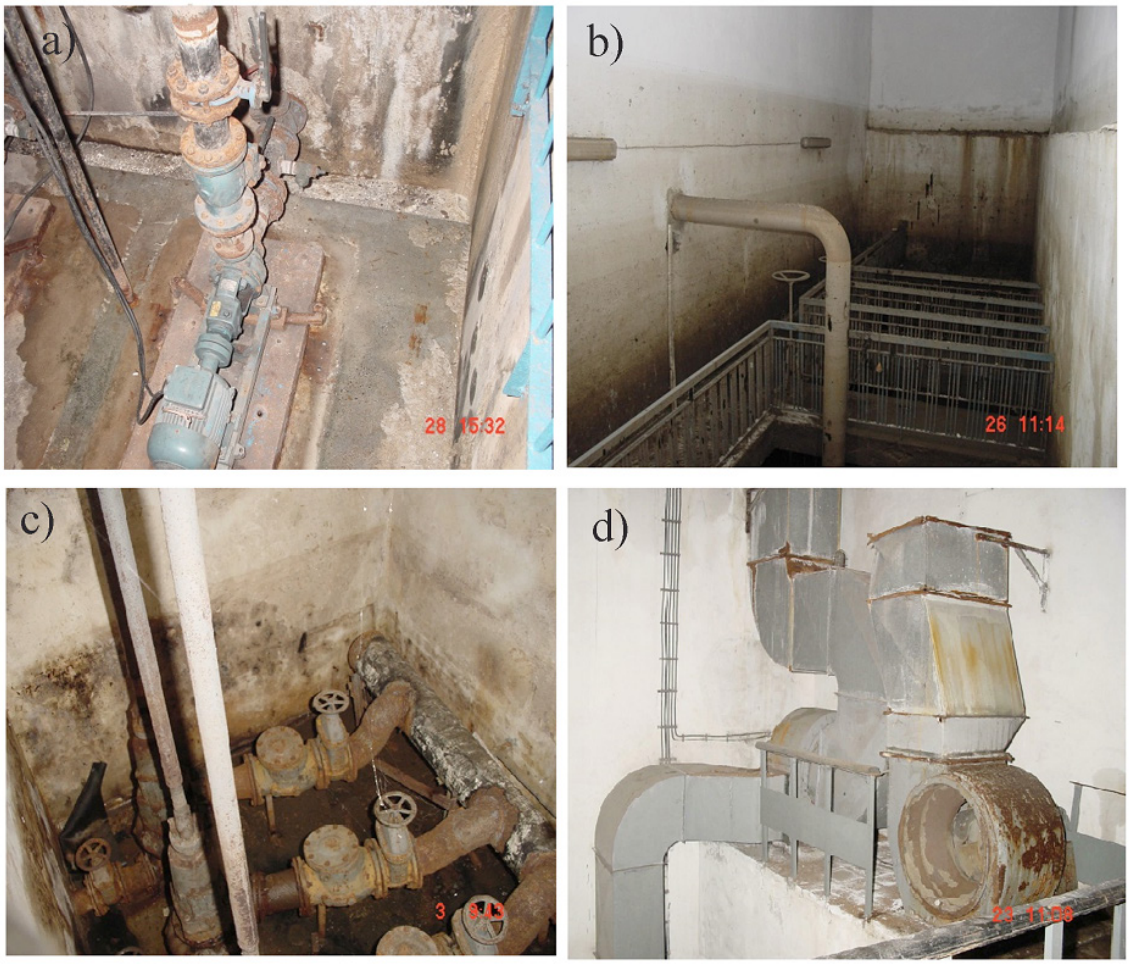

Fig. 4. (a) Concrete corrosion, (b) diver pumps, (c) concrete and steel corrosion and (d) ventilation with corrosion.

and distribution systems such as gas, oil and water pipelines. Besides control, SCADA systems also perform monitoring data logging, diagnostic functions and alarming in a safer manner and are monitored by a relatively small staff [25,26].

3. Concluding remarks

Technical research investigation shows the following critical points. Denitrification rate affects the oxygen and nitrate concentration in wastewater. As a result of model canalization system NH_3–N (20%–70%), TN (25%–75%) was obtained in the system. During the evaluation in canal, anaerobic treatment occurred. Wastewater is of domestic character and constant components. Destroying organic substances causes organic mass oxidation and reduces the oxygen amount. H_2S, mercaptans and ammonia reduce the air in collector and wastewater cleaning plants. Sulphate and ammonia gas exit as 80%–90% reducing process. Due to this situation, EM and other bacteria can be added to the wastewater.

The gases affect the corrosion indicating that treatment gases constitute picked, transferred or treated places. People and plants should be protected from the dangerous effects. Treatment gases can be removed by the help of ventilation systems. New and protective materials can be used at the plant to prevent the corrosion process. The contact places of the plant with gases can be designed by V4A stainless steel and other places can be done by zinc-coated material and also can be painted. A new automation system has been presented as an alternative way to solve the corrosion problem occurring at wastewater treatment centres.

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