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# THE PROBLEM OF MUNICIPAL WASTEWATER TREATMENT IN TASHKENT (REPUBLIC OF UZBEKISTAN)

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**Abstract.** In this paper discussed the effectiveness of three operating aeration stations in the city of Tashkent: Salar, Bozsu and Bektemir. The location of these stations and contaminants of municipal water before and after treatment has been determined. Chemical and biological point of view to find appropriate methods for treatment municipal wastewater will improve the quality of water basin and reduced influence of toxic metal ions and smell to environment as well. It should be noted that the results of wastewater treatment in these stations required provide the research to development sufficient method for apply.

**Keywords:** municipal wastewater, aeration station, aerobic microorganisms, mechanical treatment, biological purification, chemical method.

## 1. Introduction

The preservation of the quality of the environment and the health of the population is one of the most acute problems of our time. Recently, there has been a steady trend of deterioration of the ecological situation of biosphere ecosystems as a result of the influence of anthropogenic factors on them. Anthropogenic impact on the environment is a direct conscious or indirect and unconscious impact of human activity that causes a change in the natural environment and is certainly subject to all kinds of restrictions and rationing [1].

Anthropogenic factors are factors that have arisen as a result of human activity. Fresh surface waters (rivers, lakes, swamps, soil and groundwater) are exposed to the most intense anthropogenic impact. At studying the anthropogenic factor of creating unfavorable situations, it is important to take into account whether they are the result of regular and ordinary human, but environmentally unjustified activities, i.e. performed in violation of the laws of nature development or a man-made accident [2].

Aquatic ecosystems are the most vulnerable link of natural systems exposed to anthropogenic pressure in a large industrial city, and the study of the effect of wastewater on water quality in watercourses is one of the most pressing problems in a large city.

In recent years, specialists in the Republic of Uzbekistan have been paying great attention to monitoring and environmental protection. The solution of this problem, which is relevant for many countries, requires a comprehensive study of the total pollution of atmospheric air, water, soil and food, the impact of a complex of chemicals coming from these facilities on the health of the population.

The deterioration of the quality of natural waters is one of the key environmental problems in Uzbekistan. It is largely due to the discharge of insufficiently treated wastewater into reservoirs. The urgency of the problem of pollution of surface reservoirs with wastewater is associated not only with violation of environmental and fisheries requirements, but also with difficulties arising in the preparation of water for drinking and industrial water supply from polluted reservoirs.

The capital of the Republic of Uzbekistan, Tashkent - is the largest industrial city in Central Asia with a population of more than 2 million people. The city is located in an area with an arid climate, so there is an intensive use of water from watercourses and reservoirs for irrigation and recreation purposes.

On the territory of Tashkent there are about 600 large and medium-sized water users, as well as 2,600 medium-sized and small businesses that affect the city's waters. Of these, about 300 have either water intakes or discharges into open reservoirs [3].

Sewerage services (as well as water supply) in the city of Tashkent with a population of more than 2 million people are provided exclusively by the State Unitary Enterprise "Suvsoz" under the Khokimiyat* (representative authority)of the city of Tashkent. The State Unitary Enterprise "Suvsoz" carries out wastewater disposal through sewer networks and collectors, the length of which exceeded 2,634 km.

The total area of sewage facilities: 240 hectares.

The city is divided into two sewerage basins - Salar and Nizhny-Bozsusky. The beginning of the construction of sewer networks dates back to 1939, and the construction of sewer facilities dates back to the early 60s.

The drainage of the city of Tashkent is carried out from three sewage environmental protection facilities with an installed capacity of 1,945 thousand $m^3$ per day:

1. Salar aeration station – since 1961, it has been operating with a design capacity of 1120 thousand cubic meters. The productivity of the Salar aeration station is 810 000 $m^3$/day. The area of the Salar aeration station is 113 hectares.

2. Bozsu aeration station – since 1963, it has been operating with a design capacity of 800 000 $m^3$. The productivity of the Bozsu aeration station is 750 000 $m^3$/day. Currently, the efficiency of wastewater treatment is 52%. The area of the Bozsu aeration station is 120 hectares.

3. Bektemir aeration station have been operating since 1976 with a design capacity of 25 000 $m^3$/day. The area of the Bektemir aeration station is 7 hectares.

Sewage is pumped from the low places of the city by 13 pumping stations, which were built as needed at different times. There are over 98,900 wells and chambers on city sewer networks and collectors, 30 emergency discharges, 39 artificial structures through natural barriers, 78 crossings under railway tracks and 48 intersections with the metro.

In the city of Tashkent, due to its geographical features, an incomplete separate sewerage system has been adopted, in which economic - fecal and industrial wastewater is diverted from the city territory to urban treatment facilities by an underground gravity pipeline system (25-30% of wastewater is pumped by pumping stations), and stormwater, rainwater and melt water are diverted through an irrigation trough system into rivers, canals and large ditches passing through the city.

Despite the presence of sewage treatment plants, residents of Tashkent complain about the presence of an unpleasant smell, as well as the illegal discharge of sewage and waste by the enterprise. Tashkent receives clean water into its water supply system from the Bozsu canal, but sewage is drained into this canal without proper treatment. After that, more than 60 km before the confluence with the Syr Darya, the dirty Bozsu canal feeds the Tashkent region. This channel serves as a source of water for irrigation and household needs in more than 10 settlements. Thus, residents of the suburbs of the capital have to live in an environmental disaster (Figure 1).

Figure 1. The place of wastewater discharge into the Bozsu canal from the Bozsu aeration station

In Figure 1 (4 km west of Tashkent, just above the village of Nurafshon) is the Bozsu aeration station. Through two pipes visible from the shore, it drains sewage into the Bozsu canal. The station was built in 1962. Its actual capacity is 750-770 thousand cubic meters per day. This is more than a third of Tashkent's sewage. The rest falls on the Samara station at the Tashkent airport and the Bektemir facilities in Chirchik (Tashkent region).

The principle of operation of the aeration station is quite complex. Aeration, activated sludge, filters, settling tanks are used in water purification. Ideally, the water discharged after purification should not cause damage to the ecological condition of the canal. But the state unitary enterprise "Suvsoz" on its official page admits that the cleaning efficiency at the Bozsuy station is only 52% [4].

Consequently, in this article we would like to review the effectiveness of three operating aeration stations in the city of Tashkent: Salar, Bozsu and Bektemir.

## 2. Materials and methods

The incoming wastewater from three operating aeration stations in Tashkent: Salar, Bozsui and Bektemir, taken from the receiving chambers located at the aeration stations, were used as materials.

*pH value determination*

There are two methods for measuring pH: colorimetric methods using indicator solutions or papers, and the more accurate electrochemical methods using electrodes and amilli voltmeter (pH meter). The development of the glass electrode, which is convenient to use in a variety of environments, and the development of the pH meter have enabled the widespread application of pH measurement and control to take place [5].

*Total suspended matter determination*

Solid matter suspended in wastewater has long been quantified by a procedure called total suspended solids or total suspended matter, and the analytical protocol has been documented in every edition of Standard Methods [6].

*Ammonium nitrogen determination*

The ammonium nitrogen concentration in the wastewater was determined titrimetrically after distillation according to standardized method (ISO 5664).The ammonium nitrogen analyses embody two general procedural steps: distillation and titrimetric determination [7].

*Determination of total nitrogen*

Total nitrogen consists of inorganic and organic nitrogen. There are principally three procedures how to decompose all nitrogen species and transfer them into one type of measurable compounds: the digestion according to Kjeldahl, the digestion according to Koroleff by oxidation with peroxodisulfate and ignition of samples [8].

*Determination of iron*

High concentrations of iron ions in water bodies cause odour and discolouration due to their precipitation. The total iron ion concentration is generally analysed on-site by forming coloured compounds and measuring colour intensity with spectrophotometric or visual analysis [9].

*Spectrophotometric method for the quantitative analysis of phosphate in the water samples*

A simple spectrophotometric method was used to determine the phosphate content in the water sampels. The method is based on the formation of molybdenum blue complex from the reaction of orthophosphate and ammonium molybdate followed by reduction with ascorbic acid in the aqueous sulfuric acid medium. The color intensity of the molybdenum blue complex is proportionally to the phosphate content in the solution. The system obeys Lamber-Beer's Law at the 890 nm in the concentration range of 0.1-1 mg P/L and the linier calibration graph was obtained with the slope, 0.6334, intercept, 0.0074 and correlation coefficient of 0.9988. This official method was also used for the quantitative analysis of phosphate in the water samples and the satisfactory result was obtained. The range of phosphate concentration in the water samples are 0.033 – 2.943 mg P/L [10].

*Determination of sulphates*

In this study, two simple methods (conductometric titration and turbidimetric method) have been used for the quantitative determination of sulphate ions from aqueous media. Both methods are based on the reaction between sulphate ions and $BaCl_2$, when a white precipitate ($BaSO_4$) is obtained [11].

*Dissolved Oxygen (DO)*

The most commonly applied chemical method for DO analysis is known as the Winkler titration or iodometric method. Developed in 1888 by L.W. Win-kler, a Hungarian chemist, has long been the standard for accuracy and precision when measuring DO. It is a titrametric procedure based on the oxidizing prop-erty of DO. Water samples have to be collected in a specifc bottles, designed to seal without trapping air inside. An excess of manganese(II) salt, iodide (I-) and hydroxide (OH-) ions is added to a sample causing the formation of a white precipitate of $Mn(OH)_2$, which is then oxidized by the DO in the sample into a brown manganese(IV) compounds. In the next step, in acidi ・ ed solution man-ganese(IV) ions oxidize iodide ions (I-) to iodine (I2), which is then titrated with a thiosulfate solution using starch indicator [12].

*BOD determination*

According to these standards, the protocol consists of putting the samples potentially contaminated with organicmatter into specific bottles [13], aerating them, and addinga microbial population. The bottles are then hermeticallysealed and incubated in a dark room at 20°C. After an incu-bation period of ndays, the dissolved residual oxygen ismeasured for all analysed samples to estimate the BOD [14].

*COD determination*

COD is measuredas a standardized laboratory assay in which a closed water sample is incubated with astrong chemical oxidant under specific conditions of temperature and for a particular time.A commonly used oxidant in COD assays is potassium dichromate ($K_2Cr_2O_7$) which isused in combination with boiling sulfuric acid ($H_2SO_4$) [15].Conventionally, CODindexes have two types, namely $COD_{Cr}$ and $COD_{Mn}$. Determining COD using $K_2Cr_2O_7$ and$KMnO_4$ is called$COD_{Cr}$ and $COD_{Mn}$, respectively [16].

*Analysis Methods of Chloride Ions*

Three methods, namely: Mohr method, conductometric titration and turbidimetric method, are based on the reaction between chloride ions and $AgNO_3$ standardized solution [17].

*Determination of total chromium*

Both Cr(III) and Cr(VI) can strongly sorb to ironhydroxide solids forming particulate Cr(III) and Cr(VI) in water [6]. This reaction is routinely exploitedin industry to remove mg/Llevels of both Cr(VI) andCr(III) from wastewaters using iron coagulants andmaterials such as iron oxide coated sand [18].

*Determination of copper*

The method is based on complex formation of copper (II) with sulfanilic acid in acidic medium at room temperature. The complex showed maximum absorption at a wavelength of 380 nm with a molar absorptivity value of 6.7×10 -2 mol -1 cm -1 [19].

## 3. Results and discussion

The first sampling was carried out at the Salar aeration station. The territory of the Salar aeration station (SAS) is located in the southern part of Tashkent on the left bank of the Salar Canal (Figure 2).

Figure 2. Salar aeration station

The facilities were put into operation on April 12, 1961. In 1974, they were renamed Samara Aeration Station, as this name more corresponded to the nature of their technological cycle. Wastewater flows to the first stage of the building of mechanical cleaning grids from Yakkasaray, Mirabad, Mirzoulugbek and Chilanzar districts, to the second stage from Yashnabad and Sergeli districts.

The area of the Salar aeration station is 96.4 hectares .The installed capacity is 960 thousand $m^3$/day. The treatment of urban wastewater today is - 750000-850000 $m^3$/day. According to the technological process, the SAS is divided into the following workshops: a workshop for mechanical wastewater treatment and sludge treatment, a workshop for biological purification and disinfection of wastewater, a department of the chief mechanic, a department of the chief power engineer, chemical laboratories and other auxiliary departments.

Table 1 shows the results of studies on the treatment of incoming wastewater at the SAS in two emissions.

Table 1 - Results of wastewater treatment at the SAS

| № | Indicators | Meas.units | Input | After mechanical treatment | After biological treatment | Effluent 1 | Effluent 2 | Maximum permissible content |
|---|---|---|---|---|---|---|---|---|
| 1 | Temperature | град. | 20 | 20 | 20 | 20 | 20 | - |
| 2 | pH | | 7.51 | 7.28 | 7.42 | 7.42 | 7.50 | - |
| 3 | Sediment by capacity | мл/л | 4.0 | 1.4 | 0.5 | 0.5 | 0.5 | - |
| 4 | Suspended substances | мг/л | 71.0 | 41.0 | 18.5 | 16.0 | 15.0 | **23** |
| 6 | Dense residue | мг/л | 380 | 356 | 308 | 297 | 284 | - |
| 8 | Dry residue | мг/л | 426 | 396 | 336 | 313 | 308 | **486** |
| 9 | Ammonium nitrogen | мг/л | 14.32 | 12.65 | 5.19 | 4.36 | 4.17 | **6,4** |
| 10 | Nitrite nitrogen | мг/л | 0.13 | 0.08 | 0.08 | 0.098 | 0.12 | **0,18** |
| 11 | Nitrate nitrogen | мг/л | 0.31 | - | 1.26 | 1.58 | 1.65 | **9,1** |
| 12 | Common nitrogen | мг/л | 14.76 | | 6.79 | 5.83 | 5.86 | - |
| 13 | Iron | мг/л | 0.43 | 0.34 | 0.15 | 0.13 | 0.13 | **0,18** |
| 14 | Phosphates | мг/л | 2.01 | 1.52 | 0.83 | 0.69 | 0.76 | **1,9** |
| 16 | Sulfates | мг/л | 96.31 | - | - | 57.33 | 55.78 | **56,2** |
| 17 | Dissolved oxygen | мг/л | 1.68 | 2.56 | 4.73 | 5.97 | 6.03 | - |
| 18 | Oxidizability | мг/л | 40.17 | 33.19 | 16.98 | 14.64 | 14.26 | - |
| 19 | $BOD_5$ | мг/л | 41.97 | 33.4 | 18.5 | 15.81 | 14.64 | **24** |
| 20 | COD | мг/л | 137.2 | 116.27 | 67.07 | 60.29 | 59.55 | **82** |
| 21 | Chlorides | мг/л | 43.81 | - | - | 35.7 | 35.6 | **36** |
| 22 | $Cr^{+6}$ | мг/л | 0.046 | 0.036 | 0.009 | 0.008 | 0.007 | **0,008** |
| 23 | Petroleum products | мг/л | 1.96 | - | - | 0.19 | 0.19 | **0,29** |
| 24 | Koli – index | штук/л | 47000000 | - | - | 747 | 717 | **1000** |
| 25 | Total microbial number | шт/мл | 117375 | - | - | 1071 | 1209 | - |
| 26 | Synthetic surfactants | мг/л | 2.37 | - | - | 0.57 | 0.61 | **2,9** |
| 27 | Copper | мг/л | 0.019 | - | - | 0.0019 | 0.002 | **0,0025** |

After entering the Salar aeration station, the waste water passes first through a mechanical cleaning shop with garbage traps. In the building of the mechanical cleaning shop, in each channel, in front of the mechanized "fine cleaning" gratings with openings of 8 mm, "coarse cleaning" gratings with openings of 40 mm are installed to detain large waste. Further, the waste water fell into the primary radial settling tanks designed for settling suspended solids and the formation of raw sediment. The settling time is 1.5 hours. The efficiency of suspended solids retention is 40-45%.

From the 2nd line of mechanical treatment, wastewater enters directly into the aeration tanks without primary settling, due to the fact that suspended solids at the inlet average 50 mg/l. Grease traps designed to collect fats, oils, and petroleum products from the water surface using a scraper are installed on the primary settling tanks, and this sediment is pumped out using pumps into the stabilizer. Next comes the biological purification.

Biological treatment is designed to extract organic, dissolved and suspended substances from wastewater remaining after mechanical treatment. The biological cleaning workshop has 3 sections of aerotanks with a length of 60 m, a width of 40 m and a depth of 5 m. The capacity of one section is 12,000 $m^3$. The capacity of one section of the aerotank with a length of 60 m is 65 thousand $m^3$/day.

There are also 7 sections of aerotanks with a length of 108.5, a width of 40m and a depth of 5m. The capacityof one section is 21700 $m^3$. The productivity of one section of the aeration tank with a length of 108.5 m is 105 thousand $m^3$/day. In aerotanks, in the presence of oxygen, under the action of aerobic microorganisms (nitrifying bacteria), the nitrogen of ammonium salts is oxidized, resulting in the formation of nitrites, and with further oxidation of nitrates, i.e., the nitrification process occurs. One group of bacteria oxidizes ammonia into nitrous acid (nitrite bacteria), the second group – nitrous acid into nitric acid (nitrate bacteria). In the process of biological wastewater treatment, oxygen oxidation of organic substances occurs, i.e. their mineralization. For the respiration of microorganisms of activated sludge and for its constant mixing with waste water, air is supplied to the aerotank from blower units through polymer fine-bubble aerators. Aerators are mounted in three rows over the entire area of the aerotank. Then the sludge mixture from the aeration tanks enters the secondary settling tanks.

Further, the waste water enters the secondary radial settling tanks designed to separate the sludge mixture received from the aeration tanks. The sludge settles in the lower part of the sump, from where it is pumped using circulation pumps, and the clarified water is sent for disinfection. In relation to the species composition of microorganisms, the following were found in the maximum amount: *Aelosoma*, *Parameciumcaudatum*, *Vorticella*, *Epistylisplicatis, Aspidiscacostata*.

The next wastewater collection station was the Bektemir Aeration Station (BAS) (Figure 3).

Figure 3. Bektemir Aeration Station

The Bektemir wastewater treatment plant is located on the left bank of the Chirchik River in the south of the city. The Bektemir treatment plant was put into operation in 1973 with a capacity of 10 000 $m^3$/day. Phase II, launched in 1995, has a capacity of 15 000 $m^3$/day. The perimeter of the building is surrounded by a 2-meter reinforced concrete wall. At this facility, the water is purified, decontaminated and discharged into the Chirchik River. The BAS includes the following workshops: mechanical cleaning workshop, biological cleaning department, sludge treatment workshop, etc.

Table 2 shows the results of the treatment of incoming wastewater at the BAS.

Table 2 – Results of wastewater treatment at BAS

| № | Indicators | Meas.units | Input | Effluent | Maximum permissible content |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| 1 | Temperature | mg/dm$^3$ | 28.5 | 30.8 | - |
| 2 | Reaction of the medium – pH | mg/dm$^3$ | 6.8 | 8.2 | 6.5 – 8.5 |
| 3 | Sediment by capacity | mg/dm$^3$ | 2.5 | 0.2 | - |
| 4 | Suspended substances | mg/dm$^3$ | 269 | 29 | 25.0 |
| 5 | Dry residue | mg/dm$^3$ | 345 | 240 | - |
| 6 | Dense residue | mg/dm$^3$ | 800 | 455 | 1 000 |
| 7 | Ammonium nitrogen | mg/dm$^3$ | 4.3 | 2.0 | 2.0 |
| 8 | Nitrite nitrogen | mg/dm$^3$ | 0.8 | 0.2 | 0.2 |
| 9 | Nitrate nitrogen | mg/dm$^3$ | 16 | 6.4 | 10.0 |
| 10 | Common nitrogen | mg/dm$^3$ | 6.1 | 3.3 | - |
| 11 | Iron | mg/dm$^3$ | 4.5 | 1.3 | 1.5 |
| 12 | Phosphates | mg/dm$^3$ | 4.6 | 3.0 | 3.0 |
| 13 | Sulfates | mg/dm$^3$ | 363 | 97 | 100.0 |
| 14 | Dissolved oxygen | mg/dm$^3$ | 6.2 | 5.9 | - |
| 15 | COD | mg/dm$^3$ | 180 | 80 | 50.0 |
| 16 | $BOD_5$ | mg/dm$^3$ | 75 | 25 | 15.0 |
| 17 | Petroleum products | mg/dm$^3$ | 2.4 | 1.2 | 1.0 |
| 18 | $Cr^{+6}$ | mg/dm$^3$ | 1.8 | 0.09 | 0.1 |
| 19 | Chlorides | mg/dm$^3$ | 247 | 319 | 300.0 |

As can be seen from the data in Table 2, wastewater treated at BAS does not correspond to the following indicators: the reaction of the medium (exceeding the pH value), the amount of suspended solids, the values of COD and BOD, as well as the content of petroleum products and chlorides are also higher than the Maximum permissible content.

The final stage of the research included sampling at the Bozsu aeration station (Figure 4).

Figure 4. Bozsu aeration station

The Bozsu aeration station is located 4 km below the Tashkent region, on the territory of the Zangiata district and has a total area of 122 hectares. The Bozsu aeration station includes a standard list of workshops for wastewater treatment, as well as at the Salar and Bektemir stations.

Table 3 shows the results of the treatment of incoming wastewater at the Bozsu aeration station.

Table 3 – Results of wastewater treatment at the Bozsu aeration station

| **№** | **Indicators** | **Meas.units** | **Input** | **Effluent** | **Maximum permissible content** |
|---|---|---|---|---|---|
| **1** | pH | pH | 7.67 | 7.7 | 6.5-8.5 |
| **2** | Suspended substances | $mg/dm^3$ | 21.0 | 26 | 25.0 |
| **3** | Dry residue | $mg/dm^3$ | 220 | 245 | - |
| **4** | Ammonium nitrogen | $mg/dm^3$ | 5.2 | 6.2 | 2.0 |
| **5** | Nitrite nitrogen | $mg/dm^3$ | 0.56 | 1.1 | 0.2 |
| **6** | Nitrate nitrogen | $mg/dm^3$ | 4.0 | 9.1 | 10.0 |
| **7** | Iron | $mg/dm^3$ | 0.105 | 0.12 | 1.5 |
| **8** | Phosphates | $mg/dm^3$ | 0.72 | 2.0 | 3.0 |
| **9** | Sulfates | $mg/dm^3$ | 60.0 | 80.0 | 100.0 |
| **10** | $BOD_5$ | $mg/dm^3$ | 14.7 | 21 | 15.0 |
| **11** | COD | $mg/dm^3$ | 61.8 | 74 | 50.0 |
| **12** | Petroleum products | $mg/dm^3$ | 0.115 | 0.35 | 1.0 |
| **13** | $Cr^{+6}$ | $mg/dm^3$ | 0.018 | 0.02 | 0.1 |
| **14** | Chlorides | $mg/dm^3$ | 32.7 | 35.0 | 300.0 |

As can be seen from the data in Table 3, some indicators of wastewater treated at the Bozsu aeration station do not correspond to the Maximum permissible content indicators. There are: the amount of suspended substances (PDS allows 25, while the indicator after purification is 26), nitrogen indicators also exceed the norm.

## 4. Conclusion

In this article we tried to highlight the problem of wastewater in Tashkent. Residents of the Tashkent region who live in areas where treated wastewater is drained often complain to the media about pollution of open reservoirs and an unpleasant smell emanating from them. At the same time, the situation is complicated by climatic conditions. The city of Tashkent is located in a zone of sharply continental climate. In summer, the situation is particularly complicated by the windless summer heat and the temperature of +44, +46℃. A comparison of the climatic data of the city and the region obtained from the Dalverzin weather station, located about a hundred kilometers south of Tashkent, shows that in addition to global warming, the climate of Tashkent has also warmed due to the growth of the city itself and, as a consequence, the strengthening of the warming effect of the megapolis infrastructure.

According to the results of our research, it was found that the existing aeration stations do not fully cope with the treatment of incoming wastewater. Some indicators, such as the pH value, the content of chlorides, petroleum products and the amount of suspended substances exceed the maximum permissible values.

There are measures in the development plans of Tashkent aimed at the reconstruction of these stations, but the increasing anthropogenic load may lead to further search for additional ways to disinfect incoming wastewater. We believe that one of the mandatory measures is the control and accounting of waste from medium and large enterprises that regularly discharge wastewater with a certain content of pathogenic microflora. Also, the purpose of our further research is to search for new methods of wastewater treatment, taking into account the climatic features of the city, as well as the list of operating large-scale enterprises.

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