

# Influence of changes in the Volga river water expenditure on water hardness and alkalinity increase in Kuibyshev refinery river intake

N A Atanov, V A Zayko, E V Dremina

Samara State Technical University, Architecture and Civil Engineering Academy,  
194, Molodogvardeyskaya St., Samara 443001, Russia

E-mail: kafvv@mail.ru

**Abstract.** The chemical control department of the Kuibyshev refinery (known as KNPZ) registers a systematic increase in river water hardness and alkalinity. The increase of these values changes the reagent softening mode of clearing agents with weighted sediments. It is required to carry out a constant analysis of water alkalinity before reagent softening. The researchers collected data of average monthly values of the Volga-river water samples from Samara Hydroelectric Station, the Samara-river water samples from the Bezymyanka heat power-station, the Volga-river water samples from Kuibyshev refinery as well as hourly water samples from the same stations and compared it with the data on average daily Volga-river water discharge from Zhiguly hydroelectric power station, obtained in 2016, from July till October. The analysis of the data showed that changes of the Volga-river water discharge had no effect on the increase of water alkalinity and hardness of the KNPZ river intake.

## 1. Introduction

The KNPZ water intake was designed in the 1940s for industrial water supply. The water intake is located on the left bank of the Volga river. It is 3 km below the mouth of the Samara river and 2 km below the mouth of the Sukhaya Samarka river. The intake type here is a river intake. The umbrella-type intake mouth is located at a distance of 100 m from the riverbank, at a mark of 15.50 m.

The peculiarity of KNPZ river intake is its close location of the mouth of the Samara river.

The change of the water level around KNPZ river intake affects water mixture of the Samara-river water with the Volga-river water. From Monday on, the water flows into the mouth of the Samara river. The rise of the water level in the Samara river reaches the South Bridge district of Samara city.

At Volga hydro-electro station's minimum expenses, there is an increase in the Samara river sewage flow rate just by means of reduction of the water level at the mouth. In winter, the mode of the Volga river water inlet in Samara is influenced by ice cover, which reduces the level of water rise.

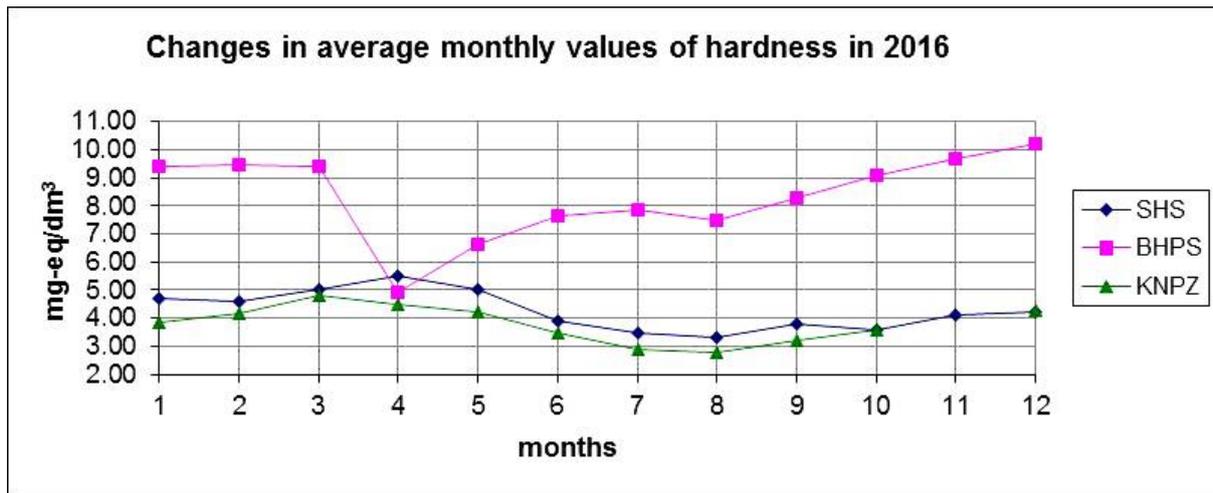
Chemical control department of the Kuibyshev refinery registers a systematic increase in river water hardness and alkalinity. Typically, the increase in hardness and alkalinity takes place between Friday and Monday. The increase of these values changes the reagent softening mode of clearing agents with weighted sediments [1-4].

## 2. Problem description

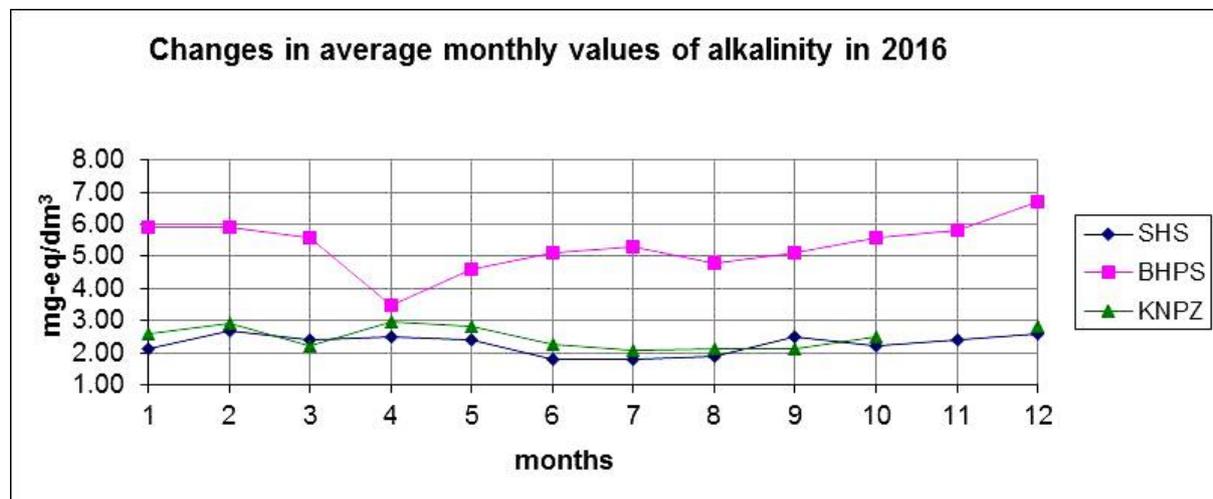


The researchers analyzed the impact of the change in the flow of the Volga river on water hardness and alkalinity increase in KNPZ river intake.

Graphs given in Figures 1 and 2 are drawn according to average monthly values of the Volga-river water samples from the chemistry department of Samara Hydroelectric Station (SHS), the Samara-river water samples from Bezymyanka heat power-station (BHPS) and the Volga-river water samples from Kuibyshev refinery heat power plant (KNPZ HPP). They make it possible to reach the following conclusions:



**Figure 1.** Graphs of changes in average monthly values of hardness of water samples (taken from the Volga river and from the Samara river).



**Figure 2.** Graphs of changes in average monthly values of alkalinity of water samples (taken from the Volga river and from the Samara river).

1. Alkalinity change in the Samara-river water (Bezymyanka HPS) is typical for a free-flow river. In such a river, alkalinity minimum value is  $A = 3.5$  mg-eq/l in the flood season (April) and the maximum value is  $A = 6.7$  mg-eq/l in December.

2. Alkalinity change in the Volga-river water (Samara Hydroelectric Station) is typical for a regulated river. In such a river, alkalinity minimum value is  $A = 1.8$  mg-eq/l in the period of water discharge from its reservoir (June-July) and the maximum value is  $A = 2.7$  mg-eq/l in February.

3. Alkalinity change in the Volga-river water (KNPZ HPP) is close to alkalinity change in the Volga-river water samples from the chemistry department of Samara Hydroelectric Station: the minimum value is  $A = 1.8$  mg-eq/l in August and the maximum value is  $A = 3.7$  mg-eq/l in April.

4. Hardness change in the Samara-river water (Bezmyyanka HPS) is typical for a free-flow river. In such a river, hardness minimum value is  $H = 4.91$  mg-eq/l in the flood season (April) and the maximum value is  $H = 10.23$  mg-eq/l in December.

5. Hardness change in the Volga-river water (Samara Hydroelectric Station) is typical for a regulated river. In such a river, hardness minimum value is  $H = 3.3$  mg-eq/l in the period of water discharge from its reservoir (August) and the maximum value is  $H = 5.5$  mg-eq/l in April.

6. Hardness change in the Volga-river water (KNPZ HPP) is close to hardness change in the Volga-river water samples from the chemistry department of Samara Hydroelectric Station: the minimum value is  $H = 2$  mg-eq/l in August and the maximum value is  $H = 5.5$  mg-eq/l in April.

The technical regulations of the reagent softening centre set the following sampling time of the source water:

- once a week for Bezmyyanka HPS;
- 7 a.m. and 7 p.m. for Samara Hydroelectric Station;
- 4 a.m., 10 a.m., 4 p.m., 10 p. m. for KNPZ HPP.

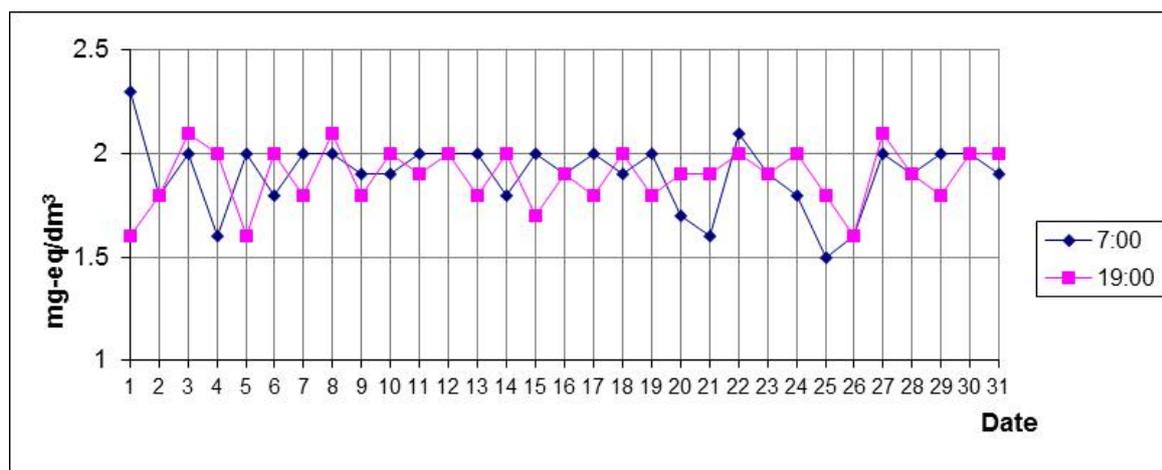
### 3. Problem discussion

The analysis of the change in the Volga-river water discharge and its influence on the increase of water alkalinity and hardness in KNPZ water inlet was made according to the data of the Volga-river water discharge at Zhiguly HPP for the period of July – October 2016.

The report contains a detailed analysis of the changes in water alkalinity and hardness for July, August and September of 2016, which shows the identity of changes in water alkalinity and hardness in this period [5-8].

This paper provides an analysis of alkalinity change in August 2016. This month was chosen because water discharge at Zhiguly HPP was at its maximum.

Figure 3 demonstrates hourly values of water alkalinity in the Volga River in August 2016 according to the data collected by the chemistry department of Samara Hydroelectric Station. This data analysis shows that:



**Figure 3.** Graphs of alkalinity change according to hourly samples taken at Samara Hydroelectric Station in August 2016.

1. The daily change of water alkalinity on August 1 was 1.2 mg-eq/l, its maximum value being 2.8 mg-eq/l at 7 a.m. and its minimum value being 1.6 mg-eq/l at 7 p.m.

2. The daily change of water alkalinity on August 4 was 0.4 mg-eq/l, its maximum value being 2.0 mg-eq/l at 7 p.m. and its minimum value being 1.6 mg-eq/l at 7 a.m.

3. The tendency of alkalinity minimal values change to their maximum values in samples taken at 7 a.m. and 7 p.m. shows rather good chemistry composition averaging.

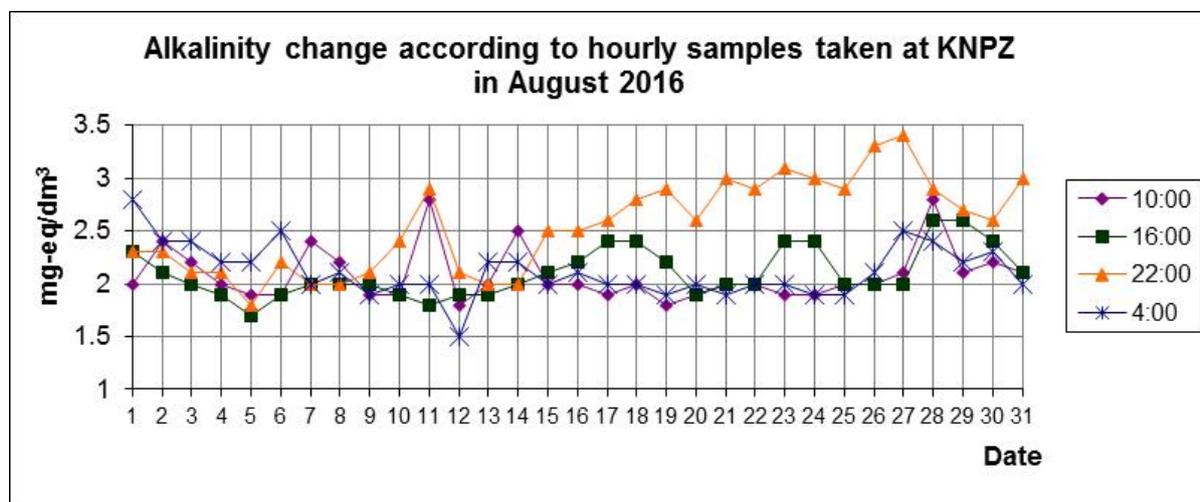
Figure 4 demonstrates hourly values of alkalinity of river water in August 2016 according to the data collected by the chemistry department of KNPZ HPP. This data analysis shows that:

1. The alkalinity values of all time samples differ in dynamics of their changes in comparison with the data obtained at Samara Hydroelectric Station (see Fig. 2).

2. The maximum daily change of water alkalinity on August 27 was 0.4 mg-eq/l, its minimum value being 1.4 mg-eq/l at 4 p.m. and its maximum value being 3.4 mg-eq/l at 10 p.m.

3. Minimum daily change of alkalinity was observed on August 8 and 9, the alkalinity value of all samples being within 1.9-2.1 mg-eq/l.

4. The maximum value of alkalinity at 10p.m. was observed in July, September and October 2016.



**Figure 4.** Graphs of alkalinity change according to hourly samples taken at KNPZ in August 2016.

Figure 4 demonstrates the following graphs for August 2016: daily discharge of the Volga-river water from Zhiguly HPP; changes in alkalinity according to the the samples taken by Samara Hydroelectric Station at 7 a.m., by KNPZ and Bezmyanka HPS at 10 a.m.; changes in alkalinity according to the the samples taken by Samara Hydroelectric Station at 7 p.m., by KNPZ and Bezmyanka HPS at 10 p.m.

The analysis of the Volga-river water daily average discharge by Zhiluly HPP makes it possible to draw Figure 5.

The water discharge mode is subject to the weekly power generation cycle.

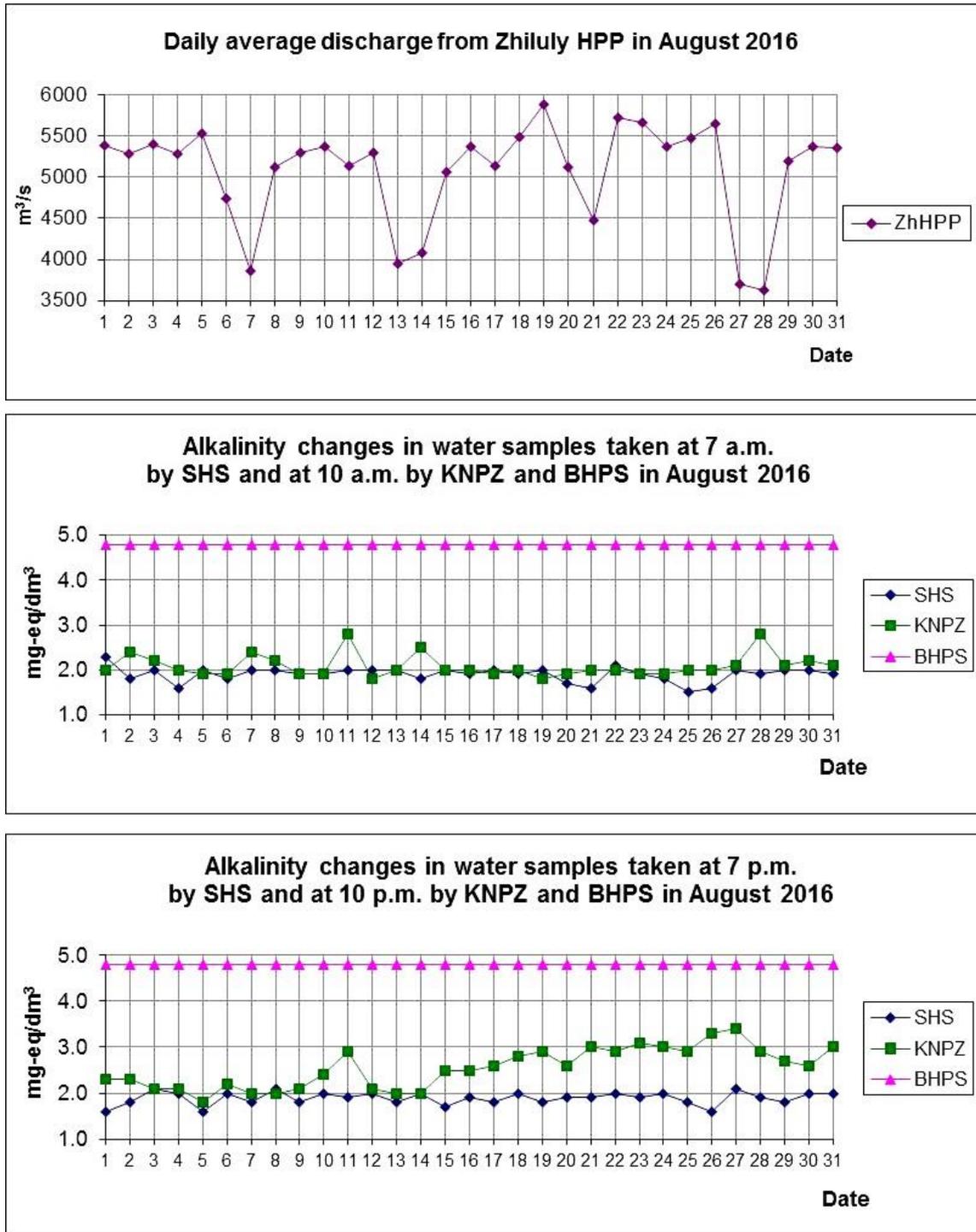
The required reduction of consumption is observed on Friday, Saturday and Sunday. Thus, on August 7, the consumption was 3800 m<sup>3</sup>/s, on August 13 – 3900 m<sup>3</sup>/s, on August 21 – 4500 m<sup>3</sup>/s and on August 28 – 3600 m<sup>3</sup>/s. The maximum discharge – 5900 m<sup>3</sup>/s – was observed on August 19 [7].

The discharge change does not affect the chemical composition of the Volga river water.

The discharge change of the Volga river water influences the change of water level near KNPZ river inlet and at the mouth of the Samara river. At the discharge of more than 4000 m<sup>3</sup>/s there provided a sufficiently high degree of the Samara river watering by the water from the Volga river.

Hydrologists found out that at a minimum expense of 1000 m<sup>3</sup>/s there was a water stream flowing along the left bank with a speed of 0.1 m/s, the average speed of the mainstream being 0.07 m/s. There was no analysis of mixing conditions, thought, done within the discharge range 1000-3500 m<sup>3</sup>/s.

It is supposed that at the minimum expenses on Saturday or on Sunday there will be an increase in alkalinity of water sample taken at KNPZ river inlet.



**Figure 5.** Alkalinity change graphs of water samples taken from the Samara river and the Volga river at 7 a.m. and 7 p.m. at SHS and at 10 a.m. and 10 p.m. at KNPZ and BHPS in August 2016.

**4. Results**

The analysis of graphs showing alkalinity changes (see Figure 5) of samples taken by Samara Hydroelectric Station at 7 a.m., by KNPZ and Bezmyyanka HPS at 10 a.m. yields the following conclusions:

1. Alkalinity of the Samara-river water (Bezmyyanka HPS) is constant – 4.8 mg-eq/l.
2. Alkalinity according to the hourly samples of the Volga water at 7 a.m. (Samara Hydroelectric Station) and water samples taken at 10 a.m. (KNPZ HPP) is identical on daily basis.
3. According to the samples taken by KNPZ, the following growth of alkalinity at 10 a.m. was observed:

- August 11: at the water discharge being 5100 m<sup>3</sup>/s;
- August 14: at the water discharge being 4000 m<sup>3</sup>/s;
- August 28: at the water discharge being 3600 m<sup>3</sup>/s.

The analysis of graphs showing alkalinity changes (see Fig. 5) of samples taken by Samara Hydroelectric Station at 7 p.m., by KNPZ and Bezmyyanka HPS at 10 p.m. yields the following conclusions:

1. The alkalinity of Samara Hydroelectric Station sample taken at 7 p.m. varies from 1.6 to 2.1 mg-eq/l.
2. The alkalinity of KNPZ samples taken at 10 p.m. varies from 2.0 to 3.4 mg-eq/l.
3. The coincidence of alkalinity analyses is observed from August 1 to August 14.
4. There is an increase in alkalinity (KNPZ) observed on August 11 at the discharge of 5100 m<sup>3</sup>/s.
5. On August 13 and 14, the minimum alkalinity of water is observed at minimum discharge costs.
6. Starting from August 14, there has been an increase in alkalinity (KNPZ), regardless of the discharge, being from 2.0 mg-eq/l to 3.4 mg-eq/l.

## 5. Conclusion

The research yielded the following conclusions:

1. The Volga river flow is characterized by a dynamic change of composition of water hardness and alkalinity, as it takes up industrial effluents of various chemical composition.
2. The discharge change from 5980 to 3600 m<sup>3</sup>/s in the Volga river has no influence on the increase of water alkalinity and hardness of KNPZ river intake water.

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