The Impacts of the Use of Chlorine-Containing Disinfectants on Water Quality under the Background of the COVID-19: A Case Study in Hong Kong

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ABSTRACT
With the advent of COVID-19, for the purpose of epidemic prevention, chlorine-containing disinfectants have been put into use in various aspects of life and medical treatment. The sudden peak in usage might put tremendous pressure on the river system. This paper takes Hong Kong as an example to find the connections behind the use of 84 disinfectants and the ecosystem during the COVID-19 pandemic. By analyzing the river water quality data of Tuen Mun River and Yuen Long River, it is concluded that the use of 84 disinfectants under the epidemic situation does have an impact on the river water quality. Finally, a reasonable and feasible treatment plan is proposed according to relevant policies.

Keywords: *Hong Kong, COVID-19, Chlorine-containing disinfectants, Water quality, Policy, Management*

1. INTRODUCTION

In 2019, the new coronavirus infection pneumonia (referred to as COVID-19) broke out in China, which lead to an enormous effect on people's health and life. The main route of COVID-19 transmission between people is through respiratory droplets and contact routes. To cut off the route of transmission, the use of disinfectants is the most effective way to block the spread of viruses. The COVID-19 has brought a lot of impacts on human life and the environment, but most of the research on COVID-19 is about the economy, so there has been little research on the topic of river water quality before. This paper discusses the possible adverse effects of the massive use of 84 disinfectant on all aspects of the environment and the solutions. Through the market survey of 84 disinfectants, this paper concludes that there is a positive relationship between their production and use and the strict control of the government after the outbreak of COVID-19. Visually analyze the relationship between the epidemic situation of Tuen Mun River and the water quality of Tuen Mun River in 2016-2020. This paper can arouse the public's attention to the environment, understand the irreversibility of disinfectants to the environment, promote the transformation of disinfectants and enhance the centralized treatment of wastewater.

2. AN INTRODUCTION TO 84-DISINFECTANT

2.1 Current Situation of Disinfectant Production in China in 2019

Common disinfectants in China market include alcohol, Tsuen, halogen, phenols and so on. The production of halogen disinfectants has reached 30%, becoming the largest proportion among many disinfectants. Therefore, taking research on the effect of 84-disinfectant on river as an example can well represent most of the disinfectants.

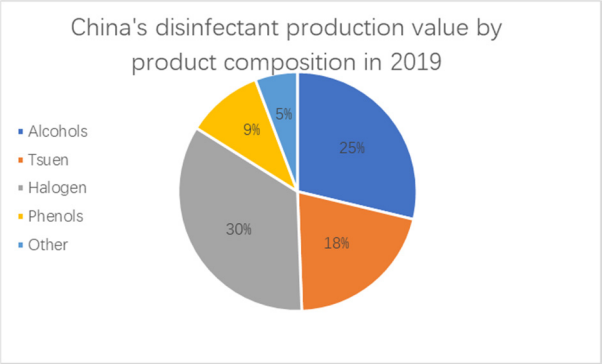

Figure 1 The China's disinfectant production value by product composition in 2019

2.2 84-Disinfectant and Residual Chlorine

84-disinfectant is a high-efficiency disinfectant with sodium hypochlorite as the main component. Sodium hypochlorite has strong oxidizing properties and can be hydrolyzed to produce hypochlorous acid with strong oxidizing properties, which can oxidize reducing substances so that the microorganisms will eventually lose their function and cannot reproduce or infect [5]. 84-disinfectant mainly remains on the surface of the object after use, and enters the surface water with precipitation, or eventually enters the soil and groundwater. After the chlorine-containing disinfectant comes into contact with water, in addition to the part consumed by oxidation, the remaining hypochlorous acid, hypochlorite and dissolved chlorine form free available chlorine, which is combined with other chemically available chlorine together make up the residual chlorine. Residual chlorine has always been an important data to show the water quality and has been recorded in rivers in Hong Kong for more than 30 years.

There are three forms of residual chlorine in water treatment [4]:

a). Free - Residual chlorine composed of dissolved hypochlorite ions, hypochlorous acid and chlorine gas

b). Combined - Composed of chloramines that can kill bacteria and oxidize organic matter

c). Total - The sum of free and combined residual chlorine

2.3 84-Disinfectant Production and COVID-19

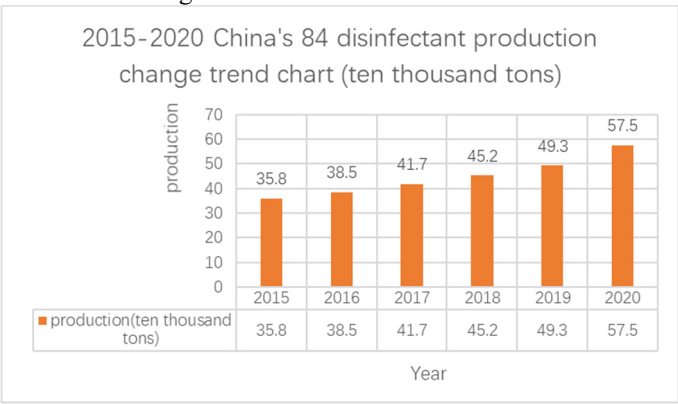

Figure 2 China's 84-disinfectant production change trend chart from 2015 to 2020 [1]

It can be seen that this data confirms that the development of COVID-19 has brought about the mass production and use of 84-disinfectant. In general, it is certain that the use of disinfectants is indeed closely related to COVID-19. Because the growth rate in 19-20 years is greater than that in previous years. According to Figure 2., the average annual compound growth rate of China's 84 disinfectant production from 2015 to 2019 is 3.38%. However, due to the spread of COVID-19, the demand for 84 disinfectants is increasing, so the average annual compound growth rate between 2019 and 2020 increased to 8.2% with the annual output in 2020 being 575000 tons.

3. THE ANALYSIS OF CHLORINE-CONTAINING DISINFECTANTS IN HONG KONG UNDER THE BACKGROUND OF THE COVID-19

COVID-19 in Hongkong broke out in early 2020. The government epidemic control is usually divided into the

following aspects: the addition of nucleic acid measurement places, restrictions on the flow of people in public places, and massive disinfection in hospitals, communities and other areas. Each control will lead to the use of a large number of disinfectants. In order to study the impact of epidemic prevention in Hong Kong on river water quality, the river water quality data of the environmental protection interaction center of the environmental protection department is analyzed. Two substandard rivers with regional and data were selected: Tuen Mun River in the northwest water control zone and Yuen Long River in the deep bay water control zone.

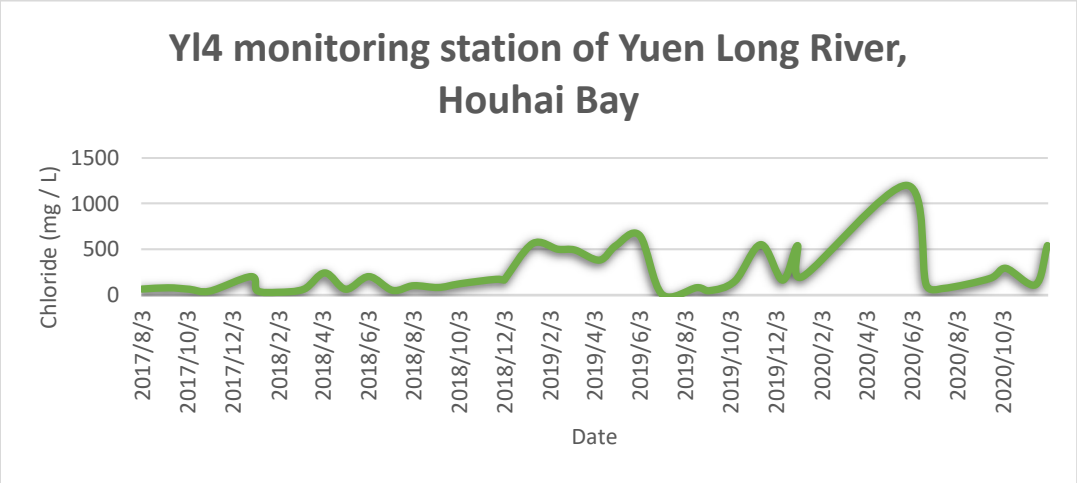

Figure 3 Chloride monitoring in Yuen Long river [6]

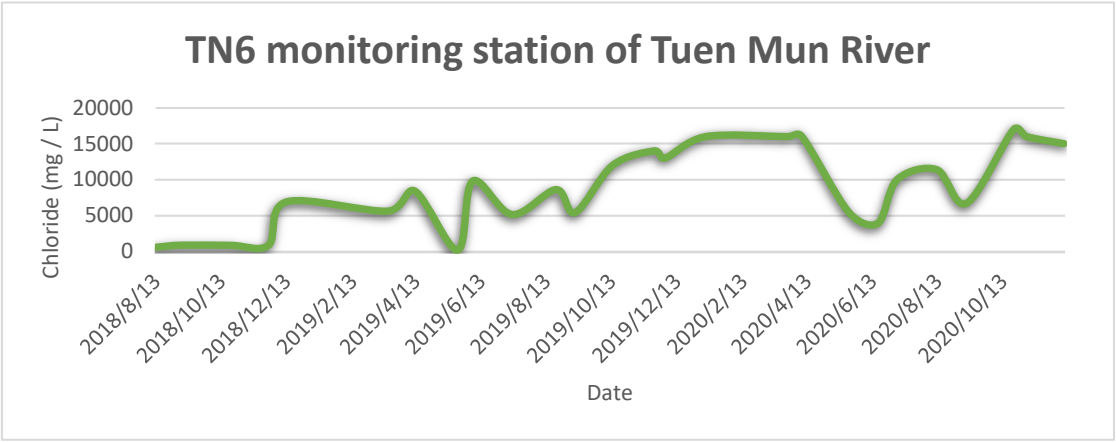

Figure 4 Chloride monitoring in Tuen Men river [6]

According to Figure4 and Figure 5, the chlorine content data of rivers in the past few years before and after the outbreak of the two groups, a significantly increasing can be seen for the chloride in two rivers after the outbreak has compared with that before the outbreak. Tuen Mun River is an artificial river. It has been facing water quality problems since 1960. Domestic sewage produced by two-thirds of the population in Tuen Mun District will be discharged into the river [14]. Compared with Yuen Long River, Tuen Mun River is a natural wide river, which can also be explained by its higher chlorine content. Therefore, its river chlorine content is also the highest among many monitored rivers. Although ClO_2 can be used to kill pathogenic bacteria in aquaculture, too high content will also cause fish death in the water. The minimum lethal dose of ClO_2 preparation for silver carp, grass carp, crucian carp, carp, catfish and soft-shelled turtle is 6.67 respectively 6.67 μg/mL、10μg/mL, 50 μg/mL, 51.2 μg/mL, 5 μg/mL, 1 600 μg/mL [2], this shows that it is difficult to find healthy fish in the Yuen Long River in Hong Kong.

4. THE IMPACTS OF THE USE OF CHLORINE-CONTAINING DISINFECTANTS ON WATER QUALITY

4.1 Impact on Surface Water

During the COVID-19, disinfectants used in large quantities enter surface water mainly through two methods. One is from sewage treatment plants discharged, another is that from the disinfectants used for community road surfaces and urban streets enter the surface water through the rainwater pipe network. The disinfectants

entering the surface water may have adverse effects on the surface water environment. Large amounts of residual chlorine can also give off a pungent smell.

4.1.1 Animal

Different aquatic organisms have different sensitivities to residual chlorine. Bai Yusai et al. showed that 0.08 mg/L residual chlorine could cause the death of larvae of Litopenaeus Vannamei, while 0.2 mg/L residual chlorine could cause the death rate of the larva of Larimichthys crocea to about 20% [11]. The study also found that chlorine-containing discharge caused a significant decrease in the reproductive rate of Oreochromis Mossambicus and the survival rate of Daphnia similis. For example, during the SARS outbreak in 2003, due to excessive disinfection, a large amount of bleaching water was poured into the Taiwan river and its tributaries. As a result, the chlorine content was too high, and a large number of fish died suddenly. It was not until six months later that returned to normal, which had a significant impact on the river ecology [10].

4.1.2 Plants

Studies have shown that when the concentration of residual chlorine in water is too high, phytoplankton will die, photosynthesis will be weakened, and the concentration of dissolved oxygen in the water will be reduced. Meanwhile, the residual of active chlorine and chloramine in the water will destroy the enzyme activity of phytoplankton, so that the phytoplankton cannot absorb nitrogen, and thus affect the phytoplankton reproduction ability [13]. After entering the water environment, ClO_2will also act on the algae chlorophyll and interrupt the synthesis of algae protein, resulting in its death. Chen Wenjuan et al. found that 1 mg/L ClO_2 can completely kill algae [11].

4.2 Impact on Groundwater

Due to a large amount of chlorine-containing disinfectant being sprayed on urban roads and residential areas, a large amount of chlorine and residual chloride ions can infiltrate into groundwater through the soil, but this needs a long-term and continuous process. Peng yingdeng said that from the current situation, lasting 1-3 months of disinfection, surface water, soil and vegetation will have a certain impact, but not serious pollution to groundwater [10].

5. THE TREATMENT OF RESIDENTIAL CHLORINE

5.1 Water System Management Suggestions

In addition to the treatment of residual chlorine and other pollutants, people can reduce the pollution caused by disinfectants from the root.

The first is to switch to a more environmentally friendly disinfectant. In fact, in this outbreak, a great number of medical alcohol has been used instead of chlorine disinfectants compared to the SARS period. Alcohol is volatile and has little impact on water quality. In addition to alcohol, other scholars found that dibromohydantoin can be used as a new generation of highly effective disinfectants. It has a low content of bromide after decomposition and low pollution to the environment. A study conducted by the School of Life Sciences at Shenzhen University showed that after disinfecting papaya and mango with dibromohydantoin for 10 minutes, the bromine content per 100 grams of fruit was less than 0.35 mg, which met the national standard [9]. This suggests that chlorine disinfectants can be developed and used to reduce pollution with more environmentally friendly alternatives.

The second is to improve our water system. The pollutants in water generally flow into groundwater and surface water in two ways. The first is discharged into surface water through a rainwater pipeline system, and the second is discharged into a sewage treatment plant through a sewage pipeline and then merged into the surface water domain after treatment. It can be separated from the source of water pollution moderately and flow into reasonable pipes, that is to say, the drainage pipes of the city should be properly planned. In the current outbreak, a large amount of wastewater containing residual chlorine from household disinfectants was also discharged into public sewage pipes. This part of the chlorine effluent should be treated properly before discharge.

5.2 Possible Solutions to the Residual Chlorine in Rivers

Possible solutions to the problem there are several possible solutions to the challenge of chlorine pollution. The use of high-efficiency softeners and less salt in softeners can help reduce the chlorine content of cities. Lime softening details the softening process of lime can be carried out in different ways. The softening of lime and lime-soda ash is usually composed of chemical raw materials, rapid mixing, flocculation, sedimentation and re carbonation [7].

5.3 Discharge Standard of Residual Chlorine in China

Due to the use of a large number of disinfectants in the epidemic, Hong Kong government has raised the discharge standard of residual chlorine in rivers to 6.5mg/l [3]. The national residual chlorine emission standards for other industries are shown in Figure 6.

Industry	Standard
Residual chlorine in swimming pool	0.3mg/L~0.5mg/L
Residual chlorine in tap water	0.3mg/L~0.4mg/L
Residual chlorine in hospital dialysis unit	≤5mg/L
Residual chlorine in aquaculture industry	0.3mg/L~0.5mg/L
Residual chlorine in hospital waste water	3mg/L~10mg/L
Residual chlorine in dringking water	≤5mg/L

Figure 5 The standard of residual chlorine industry in China

6. CONCLUSION

This paper mainly studies the impacts and improvements of 84-disinfectants on water quality in the new crown epidemic. Generally speaking, a great quantity of using the chlorine disinfectants during the COVID-19 period will have a great impact on the circulating water environment. The data from generous rivers in Hongkong, China are inferred: the residual chlorine in rivers produced by the by-products of 84-disinfectant after being discharged into the river with domestic water and industrial wastewater will carry out advection, dispersion, diffusion and retardation of underground water until the residual chlorine concentration then reached the normal content. However, before the residual chlorine content reaches the standard, excessive residual chlorine will cause damage to animals and plants in surface water and groundwater. It can be seen that the residual chlorine content in rivers does have significant growth and potential hazards, even if all kinds of hazards cannot be reflected in a few years. The paper also puts forward some feasible methods to deal with the residual chlorine in rivers and advocates the use of more environmentally friendly disinfectants, such as alcohol.

This paper only qualitatively analyzes the water quality, bur does not use the modeling method to quantitatively study the diffusion and flow of residual chlorine. Future research can further study on the three-dimensional movement, diffusion and decomposition of river pollutants in surface water and groundwater.

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