Optimization of Building Drainage System Based on Blocking the Transmission Route of Pathogenic Bacteria

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Abstract. Some pathogens exist in the way of fecal oral transmission, while the risk of building drainage pipeline is easy to be ignored and hard to be eliminated. It is worth to reflect on the SARS incident in Taoda garden in Hong Kong, in case of group infection. At the same time, the transmission chain of pathogenic bacteria is analyzed, and according to the transmission chain, the idea of system optimization or solving the transmission of pathogenic bacteria is put forward.

1. Introduction
On February 1, 2020, Shenzhen Third People's Hospital tested positive for viral RNA in the feces of confirmed patients. At the same time, in Kang Mei Building, Qingyi Changkang, Hong Kong, two residents living in rooms 07 on different floors were confirmed cases, which the Hong Kong Department of Health considered to be related to building drainage pipes. This means that there is a possibility of fecal-oral transmission of the new coronavirus infection, making it more difficult to fight the epidemic. Therefore, for pathogenic bacteria such as new coronavirus (2019-nCoV), which are at risk of fecal-oral transmission, another focus of transmission still needs to be paid attention to: drainage pipes in buildings. Building is the place where people live and live, and it is very critical to ensure the health conditions in the building.

2. Relationship between Building Drainage Pipelines and Hazardous Gases
Taking modern residential buildings as an example, indoor drainage pipes connected with drainage pipes are basically divided into three categories: kitchen drainage pipes, toilet drainage pipes, and balcony drainage pipes. In some areas, the domestic drainage system is further divided into the domestic sewage drainage system for washing toilets and the domestic sewage drainage system for washing and washing wastewater [1, 2]. The kitchen water pipeline and the balcony water pipeline belong to the domestic wastewater drainage system, and the number and species of pathogenic bacteria are smaller than the domestic sewage drainage system [3–5]. But for domestic drainage systems that do not distinguish between wastewater and sewage, harmful gases are more likely to pollute other residential rooms due to the lack of liquid-sealed storage pipes in kitchen and balcony drainage pipes. If the community is still using septic tanks, harmful gases are generated when the organic matter in the septic tanks is anaerobically decomposed, and are brought up into other residential rooms through sewage pipes. In fact, anaerobic decomposition will produce a certain
amount of gas regardless of whether septic tanks are used in the community or not, resulting in a certain transmission possibility.

Toilet drainage (domestic sewage drainage system)

Toilets have relatively poor ventilation due to their small size. Therefore the toilet drainage pipeline is generally equipped with U-shaped pipe as a water storage bend [6]: in terms of health, the function is to act as a liquid seal, using water and other liquids to intercept harmful gases in the drainage transverse branch pipe. The floor drain of toilet is a big hidden danger. Because of the lack of water or the dryness of water, the floor drain can not act as a liquid seal, which may lead to the entry of harmful gases [7].

In summary, the current building drainage pipelines have partial air insulation effect [8], some old communities or domestic drainage systems that do not distinguish between wastewater and sewage will have a greater risk of harmful gases entering the room.

Taking SARS with strong infectivity as an example, the relationship between building drainage pipeline and pathogen transmission can be analyzed. In 2003, SARS virus emerged, and the main route of transmission included fecal-oral transmission. This route led to an unprecedented large-scale infection in Taoda Garden in Hong Kong in the short term [7]. According to epidemiological and environmental investigations, the reason was that a man was diagnosed with diarrhea in a room of Taoda Garden after using the toilet, SARS virus spread to other household rooms through drainage pipes. The specific propagation chain is shown in Figure 2(a):

![Figure 1. Toilet drainage (domestic sewage drainage system).](image)

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![Figure 2. SARS transmission chain at Taoda garden, Hong Kong.](image)

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a. Infectious Chain of "Taoda Garden"  b. Schematic Diagram of Transmission Pathway
According to statistics from the Hong Kong Department of Health, the proportion of household infections with confirmed patients and sewage pipes ranked first in the Taoda Garden incident, and the possibility of contaminating other households through underground sewage systems was not excluded. For buildings, solids carrying pathogens do not contaminate other households. But insects and aerosols (see Figure 3) can carry pathogens into other residential rooms.

![Figure 3. Terrace drainage at Taoda garden.](image)

Some pathogens can survive up to 24 hours in droplets such as droplets, such as the novel coronavirus (2019-nCoV). In addition, viral RNA was detected positive in the feces of confirmed patients [9], which means that some pathogenic bacteria also have a certain survival time in the living drainage system [10-11]. In the event of Taoda Garden, many households found that U-shaped water reservoir had good liquid seal water after inspection. Then in the chain of transmission, there is another possible way: the aerosol carries pathogenic bacteria, even mixed with the water forming the liquid seal, and the pathogenic bacteria survive in the water for a certain time. This pathway is easily overlooked and much less avoidable.

3. Optimizing Conception of Building Drainage Pipeline System
In current construction facilities, environmental workers are obliged to make improvements to reduce the transmission routes of viruses, given that pathogens still have the potential to be transmitted from the patient's home to other households through the drains of the building. Therefore, according to the transmission chain of pathogenic bacteria (see Figure 2), it is of practical guiding significance to specifically analyze each transmission link and give suggestions or optimization ideas.

3.1. Separated domestic drainage system
Domestic drainage system refers to the discharge of sewage and wastewater from residential buildings, public buildings, etc. For the need of wastewater treatment, sanitary conditions or miscellaneous water, the domestic drainage system is classified as the domestic sewage drainage system to remove toilet and washing wastewater and the domestic wastewater drainage system to remove toilet and washing wastewater. And the domestic wastewater after treatment can be used as reclaimed water [12], to flush toilets, sprinkle green space and roads, etc. Of course, during the epidemic, it is recommended that the reclaimed water be stopped, all merged with the domestic drainage system, and discharged to the terminal water treatment plant for treatment.

3.1.1. Strengthen separated system within the community. When economic conditions permit, it may be considered to refine the shunt system. In the community, the two drainage systems of domestic sewage and wastewater are separated physically first, and then combined operation is considered when the water is purified by the water treatment plant. In order to avoid harmful gases generated in underground pipes in the community or pathogens entering the wastewater system from the sewage
system, and entering other residential rooms through indoor drainage pipes without air insulation (except toilets).

3.1.2. Single household sewage and drainage system. In residential buildings, the inhabitants are independent and physically barrier. And in order to have a more comfortable and healthy life, the future development of buildings is also tending to be more independent, such as water, electricity and heating, which has long been independent of each household. Therefore, it can be considered to take the lead in making the sewage and drainage system independent of each household when it is economically feasible: to make the sewage and drainage system independent of each household in the building, choose to merge the urban drainage system or the terminal water treatment plant, which can greatly prevent the cross-infection caused by the drainage system such as "Taoda Garden Event".

3.2. Underground drainage system in buildings
Underground drainage systems are connected with sewage pipes in buildings, and pathogenic bacteria also have the potential to migrate to infected residents through underground drainage systems into sewage pipes in buildings [13].

3.2.1. Shorten the time of building drainage pipes to city drainage system. The groundwater main drainage pipeline of the building needs to pass through the underground drainage system of the building. It can reach the urban drainage system after a certain time, and finally reach the terminal water treatment plant. At the same time, some pipelines have set up interception pools, which prolong the sewage residence time. During periods of large infectious diseases, it is recommended to reduce the time from construction drainage pipelines to urban drainage systems in order to reduce the risk of infection. This action is not to let the interception pond and other water do not play its due role in degradation, but the terminal water treatment plant has more abundant treatment experience and scientific researchers, can make a good judgment and treatment of such water.

3.2.2. Reduction of septic tanks. As a traditional environmental protection facility with a history of more than 100 years, septic tank has played an important role; however, with the progress of society and the development of urban modernization, the function and effect of septic tank have fallen behind the current social development [14]. Firstly, the harmless treatment of fecal sludge is insufficient, leading to the incomplete removal of pathogenic bacteria, but with the trend of anaerobic decomposition gas migration. Moreover, extensive management of septic tanks, such as sludge removal and transfer, is very likely to cause secondary pollution. In addition, the pool body is easy to leak and is not friendly to the environment.

Generally, septic tanks have played a role in the past, but at present it is desirable to place more emphasis on a healthy and comfortable environment, reduce or cancel septic tanks [15].

3.3. Solid-liquid-gas unidirectional passage
The economic cost of strengthening the shunt system is not small, so simple engineering measures will be more practical. Hazardous gases and aerosol particles in the aforementioned pipelines carry pathogenic bacteria and migrate to residential rooms.

![Figure 4. Solid-liquid-gas unidirectional flow through the device is visualized.](image)
Then it can be considered that in the case of relatively small drainage resistance, a similar to Figure 4 is added between the residential drainage transverse branch pipe and the drainage main branch pipe of the whole building: the fixed point is located above the midline, and the gas can be blocked vertically to migrate into the transverse branch pipe due to gravity when not draining.

The design of this type of one-way passing device needs to take into account air resistance, air pressure, power resistance and other issues. If these problems can be well balanced and a certain degree of solid-liquid-gas unidirectional passage is guaranteed, then the problem of pathogenic bacterial contamination of building drainage pipelines can be solved at a small economic cost.

4. Conclusion

Novel coronavirus (2019-nCoV) and other pathogens are the risk factors of fecal transmission. The transmission of the building's drainage pipelines may lead to a group infection similar to the 2003 Amoy garden incident. From the point of view of safety and health [16], it is significant to reduce the spread of harmful gases in the horizontal branch pipe of the household, while the pathogens with greater risk are considered to be the need to take measures to cut off the transmission chain of "horizontal branch pipe - building main sewage pipe - underground sewage system" in the household. In the optimization of drainage system, we should consider not only the economic cost of the city but also the actual effect.

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