Status of Membrane Filtration in Japan

Application for Water Supply

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1. Introduction

In Japan, the membrane filtration is becoming a common technology for municipal water supply system especially for small plant. 6 years before (1991), the national research project of membrane filtration for small plant has started. The project was named as "MAC 21" , MEMBRANE AQUA CENTURY 21. In the project the Ministry of Health and Welfare, 8 universities and 18 water treatment plant companies have been involved. This was the first attempt to research a common theme in joint with government, universities and private companies. (官・学・産 共同研究) After three years, the guide line for membrane filtration application for small plant has been established.

This has promoted to install some actual plant.

And also, another joint research for "RESEARCH OF MEMBRANE FILTRATION FOR ADVANCED WATER TREATMENT" has started in 1994 and completed in March, 1997. The project was named as 高度 MAC21.

In the former project the main objectives were removal of turbidity and bacteria from water. However, in new project the objective was establishment of the further advanced membrane filtration technology which would be applicable for trace chemical components removal such as tri-halo-methane pre-courser, agricultural chemicals removal, offensive smell and taste removal and virus removal. For the objectives, application of nano-filtration and hybrid-system, a combination of micro-filtration/ultra-filtration with biological , ozone and activated carbon treatment process have been studied. In addition, application of membrane filtration for treatment of back-wash waste water originated from membrane filters and conventional sand filters has been studied.

At the end of March of this year, about 30 membrane filtration plants are actually supplying the water, the total treatment capacity is about 6,000 m3/day and another 20 will be installed within one year.

2. Membrane used for water supply

Many types of membrane filtration system are proposed and applied actually. The membrane is classified into two categories ; i.e. ultra-filtration(UF) and micro-filtration(MF). Operation method can be classified ; cross-flow/dead-end filtration : external/internal pressure : pressure vessel/tank-submersed. The material is also varied depending on the membrane. At the stage, it is very difficult to predict the best system and in several years a actual performance will make conclusion.

The types proposed by Japanese manufactures are as follow.

2.1 Ultra filtration

Type Of Membrane	Filtration Method	Material
hollow fiber	cross flow : pressured vessel inner pressure type (water flows inside to outside)	cellulose acetate PAN
	cross flow : pressured vessel external pressure type (water flows outside to inside)	cellulose acetate PAN(polyacryronitrile) polysulfone
	tank-dipped filtration external pressure	polyethylene

2.2 Micro filtration

Type Of Membrane	Filtration Method	Material
hollow fiber	cross-flow external pressure	 PP(polypropylen) PAN(poly-acryronitrile)
	tank-submerged external pressure	PS(polysulfone)
hollow fiber	cross-flow external pressure	polysulfone polypropylene
hollow fiber		
tubular	tank-submerged external pressure	ceramic
monolith	dead end internal pressure	alumina
plain plate	tank-dipped outer pressure	poly olefin

3. Combined system(hybrid system)

The system consists of MF/UF with additional advanced treatment for contaminated raw water to which MF/UF alone can not be applied. MF/UF can remove turbidity and bacteria almost perfectly but to remove THM pre-courser, agricultural chemicals, offensive smell and taste and to prevent biological damage of membrane filter itself some additional treatment are required.

As additional treatment biological treatment, ozone treatment and activated carbon treatment have been studied. As a result, it becomes clear that application of the hybrid-system for further contaminated raw water is very effective. The selection of each system flow will depend on the raw water quality and some additional experience will be required to establish a process flow selection know-how.

At the stage still no actual plant has been installed, however in few tears some plants will be expected.

Examples of proposed hybrid system

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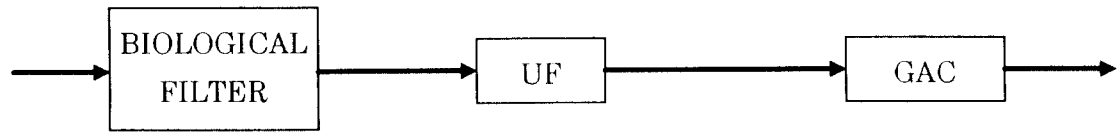

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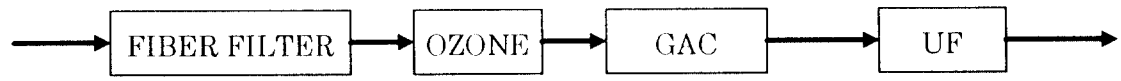

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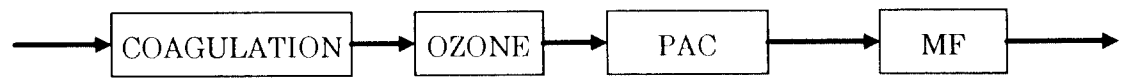

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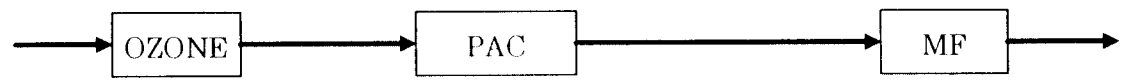

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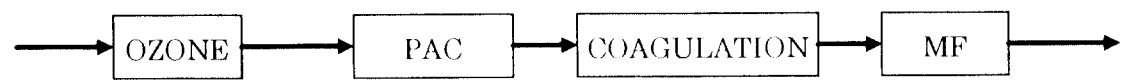

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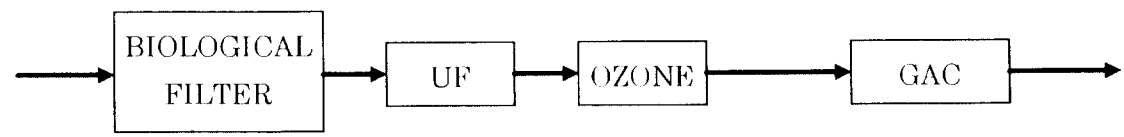

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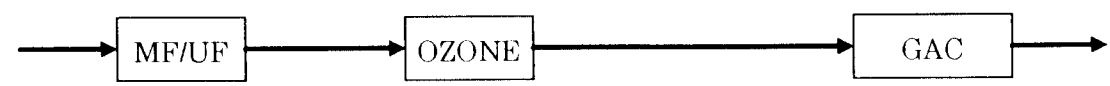

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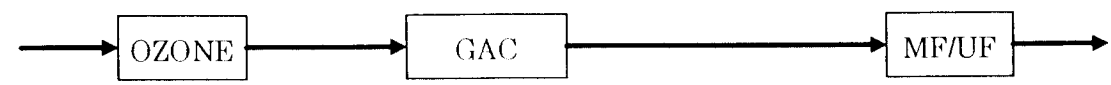

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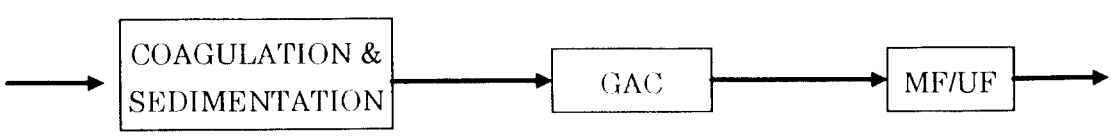

3. Nano-filtration

The main objective of nano-filtration is removal of THMs pre-courser components which cause disaffection by-products formation. At the stage, the nano-filtration itself is a new technology in membrane filtration field and still under developing. The nano-filter membrane is situated at middle position between "ultra-filtration membrane" and "reverse osmosis membrane". Structure and characteristics of the membrane are very close to the reverse osmosis membrane and it is classified as of charged membrane. This causes a high separation of dissolved matters but on the other hand the higher membrane differential pressure is required comparing to micro-filtration(MF) and ultra-filtration(UF). It is very important to select the membrane which is suitable for object components to be removed and to descried the optimum operation conditions.

(1) Pre-treatment

The nano-filtration membrane requires a higher turbidity removal for pre-treatment to prevent membrane clogging. Generally, the required level for the pre-treatment is less than 4 of FI value.

To achieve the value of FI 4 , coagulation-sedimentation with single layer sand filtration by Polly-aluminum-chloride(PAC) is not suitable even though operating with the lower filtration rate.

When using the dual layer filter with anthracite and sand, normal PAC dosing is not suitable as the pre-treatment but the lower pH control with acid with PAC results a better performance. However, PAC with lower pH control is not always steady to achieve less than FI4. A certain raw water quality changes which can not be identified will make a poor performance. Application of ferric-chloride (FeCl3) will give the better result than PAC.

In the case of MF and UF, the target FI 4 can be expected constantly.

(2) Removal of contamination component

The nano-filtration gives a higher removal ratio for color, potassium-permanganate consumption, THMFP and TOC. Besides the above listed organic contaminants agricultural chemicals can be removed effectively.

A typical data :

Color: almost 100 %, KMnO4 :more than 95%, THMFP: 70 to 100 % (depending on the membrane used), TOC : more than 90%.

(4) Salt rejection

As mentioned above, the NF membrane is close to RO membrane and some extend of desalination occurs. The higher desalination makes the poor taste to drink. However, to select the suitable membrane with lower salt rejection characteristic will result less than

50 % reduction of hardness component.

A further research and development of the membrane manufacturing technology is expected for higher contaminants removal but less salt rejection membrane.

(5) Operating condition

The important factors to be considered for application of NF for water supply are energy consumption and water yield ratio. The following is a typical data for NF.

Operating pressure of the NF : 0.3 to 1.0 MPa

Yield ratio: 50 to 90%

Recently, new membranes with the higher flux and the lower operating pressure are developed and come into market in Japan. These membrane will promote the application of NF for water supply after some long-term verification.

4. Conclusion

The application of membrane filtration (MF and UF) for municipal water supply is becoming a common technology in Japan. At the stage, the application is limited to rather small scale plant. However, it is reported that there is a project to install a bigger plant with capacity of more than 5000 m3/day within two years. And also, as mentioned above, the new joint research for membrane filtration has completed and the higher applicability has been anticipated.

I hope in 21st century the membrane filtration will succeed the rapid sand filtration system which has been used for more than one hundred years as a key technology for water supply.