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Decontamination of Radioactive Iodine Using Various Filters

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In connection with the East Japan great earthquake, the radioisotope by the accident of the first nuclear power plant of Fukushima was emitted. The radioisotope which exceeds a fiducial point in water purification plants, such as Kanamachi Purification Plant, was detected, and purification of radioactive contamination water is needed. Moreover, the high concentration contaminated water in a nuclear power plant is emitted to the sea, and quick decontamination is pressing need. The purpose of this research is purification of radioactive contamination water.

The removal experiment of radioactive iodine 131 was conducted using various water-purifying filters. As a result, the extraction ratio of a maximum of 99.6% was shown. Thereby, a water-purifying filter has the decontamination effect of radioisotope, and suggested the possibility of large-scale purification of high concentration contaminated water.

Key words: Decontamination, Fukushima nuclear power plant, Earthquake, water-purifying filter, Radioactive iodine, Dosimetry

1. Introduction

The accident of the first nuclear power plant of Fukushima is the cause that the value with a high air dose of Fukushima Prefecture is shown. Soil pollution is observed and the work which removes the topsoil of the schoolyard of elementary and junior high schools is done[1]. It is in the situation which cannot drain the water which was anxious also about contamination of the swim pool by scattering and deposition of radioisotope[2, 3], and was filled in the pool as an object for fire prevention of winter. Zeolite is used in the contaminated water processing in a nuclear power plant. It is a minus electric charge and adsorbs radioisotope in porosity. However, it is a problem to get the impurities of contaminated water blocked. In this research, the water of this swim pool is purified and fundamental research for it is done aiming at making drainage possible to a common sewer.

The purpose of this research is purification of radioactive contamination water. It made to enable use of a swim pool, to realize reduction of the inside and external dose of radioactivity of a student and a school staff, and to secure a healthy life into the policy objective.

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2. Methods

The activated carbon filter (stem 2 type) by Chisso Filter Co., Ltd., the ion-exchange resin (Amberlite MB-

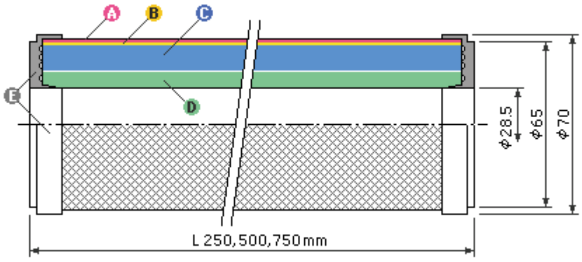

Fig. 1. The activated carbon filter.
(http://www.jnc-corp.co.jp/filter/product/stem/index.html#shiyo)
(A) Outer layer protection net
(B) Primary filter
(C) Adsorption layer (activated carbon particle size)
(D) Secondary filter
(E) Gasket

Photo. 1 The activated carbon filter. (Chisso Filter Co., Ltd.)

2) by ORGANO CORPORATION, RO (Reverse Osmosis) reverse osmosis membrane (ESPA-1812, ESPA-4021) made from Hydranautics Corporate was used as a water-purifying filter which verifies water disposal technology. The activated carbon filter was shown in Figure 1 and Photo.1. It has three-layer structure and the polyolefin system composite fiber (ES fiber) is used as primary filtration. The second layer is adsorption layers and is manufacturing the coconut husks activated carbon of materials by Activation by Steam. The third layer is secondary filtration and collects detailed particles with CP filter. The ion-exchange resin for tap water was shown in Photo.2. Basic structure is a styrene system and is the reproduced type mono-bed resin which set the rate of positive ion exchange resin and anion exchange resin to 2 to 1. Density is 705 g/l. RO reverse osmosis membrane used the home small RO film and industrial RO film, as shown in Figure 2, 3 and Photo. 3, and 4. Configuration is spiral wound and membrane polymer is composite polyamide. Maximum feed flow is 11 liter per minute. Purification processing was performed by using the radioactive iodine 131 of 0.3, 3, and 300 kBq/l as contaminated water. In each filter, processing time of

Photo. 2 The ion-exchange resin. (ORGANO CORPORATION)

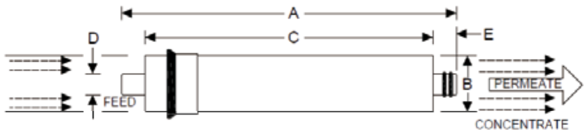

Fig. 2. The home small RO reverse osmosis membrane.
(http://www.membranes.com/index.php)
A, inches (mm) 11.74 (298)
B, inches (mm) * 1.78 (45.2)
C, inches (mm) 10.0 (254)
D, inches (mm) 0.68 (17.3)
Dry Weight, lbs. (kg) 0.5 (0.23)

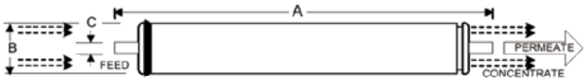

Fig. 3. The industrial RO reverse osmosis membrane.
(http://www.membranes.com/index.php)
A, inches (mm) 21.0 (533.4)
B, inches (mm) 3.95 (100.3)
C, inches (mm) 0.75 (19.1)
Weight, Ibs. (Kg) 4 (1.8)

contaminated water is about 30 minutes using 50 liters. Measuring using the well type NaI scintillation detector, the measurement sample was 1ml. The energy calibration of the detector used standard radioactive cesium 137. The multi-channel analyzer's channel ratio and energy were adjusted, and the spectrum was analyzed. The detection limits of a well type NaI scintillation detector are 0.1 cpm.

3. Result and Discussion

The count and decontamination ratio of the contaminated water processed with various filters were shown in Table 1. The measurement number is 10 times and an average and standard deviation of measured value are indicated. The background shows 10 cpm and the count in Table pulls this value. The decontamination rate of the radioactive iodine 131 of [0.3 kBq/l] using an activated carbon filter

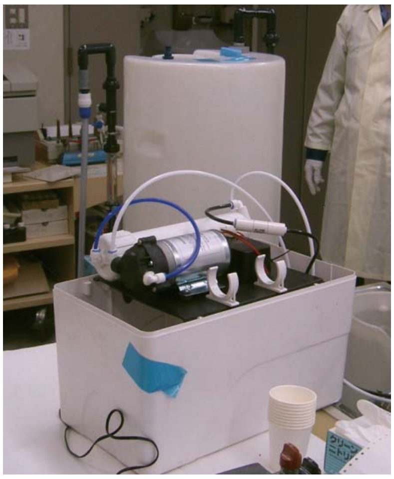

Photo. 3 The home small RO reverse osmosis membrane.

Photo. 4 The industrial RO reverse osmosis membrane.

Table 1. The count and decontamination rate of the radioactive iodine processed with various filters

		Contaminated water	Activated carbon filter	Ion-exchange resin	Small RO reverse osmosis membrane for home	Industrial RO reverse osmosis membrane
0.3 kBq/l	Count (cpm)	19.8 ± 8.1	10.2 ± 6.2	5.0 ± 3.5	3.8 ± 1.8	5.6 ± 4.0
	Decontamination rate (%)	—	48.5	74.7	80.8	71.7
3 kBq/l	Count (cpm)	90.0 ± 13.2	34.8 ± 6.8	14.6 ± 4.3	16.2 ± 5.0	21.0 ± 6.6
	Decontamination rate (%)	—	61.3	83.3	92.0	76.7
300 kBq/l	Count (cpm)	6568.6 ± 76.5	1392.2 ± 57.6	27.2 ± 5.5	682.0 ± 56.6	1016.6 ± 53.4
	Decontamination rate (%)	—	78.8	99.6	89.6	84.5

was 48.5%. The decontamination rate was proportional to activity concentration. The decontamination rate of an ion-exchange membrane and RO reverse osmosis membrane was also proportional to activity concentration, and ion-exchange resin showed the decontamination rate of 99.6% in the radioactive iodine 131 of 300 kBq/l. It is because big variation and the probability purified fall in low activity concentration. Generally the number of atomic is not activity concentration, and it is expressed with the measurement value of radioactivity.

In each filter, the decontamination rate of ion-exchange resin was the highest, and it became the order of RO reverse osmosis membrane and the activated carbon filter. This cause was considered because iodine exists in the state of ion. The radioactive iodine used by this research is iodinated 131 methylnorcholestenol. A molecular formula is $C_{27}H_{45}O^{131}I$. As a state of ion, the possibility of iodic acid is high. Other causes are the structures of ion-exchange resin. Ion-exchange resin is porosity and took in many radioactive iodine. If the combination of a filter is considered based on this disposal method, the turn of an activated carbon filter, RO reverse osmosis membrane, and ion-exchange resin is effective. It will become 0.00911% if the remains rate of this combination is calculated with this decontamination ratio. Thereby, the contaminated water of 1 MBq/l can be decontaminated to 91 Bq/l of a fiducially point. The home water purifier consists of an activated carbon filter and a RO reverse osmosis membrane, and a remains rate becomes 2.2%. This composition can decontaminate the contaminated water of 4500 Bq/l to 99 Bq/l.

In this research, 50 liter of contaminated water was put into the container made from polyester. It fully agitated in this container and contaminated water was extracted. Radioactive iodine is radio colloid in contaminated water, and it may have adhered to the inner surface of a wall of the container made from polyester. When performing filter processing, there is no churning structure. The contaminated water of this container is extracted and radioactive iodine may not have reached even to a filter after purification processing. It is thought that the probability is proportional to concentration, and it seems that it is one cause of an extraction ratio rise.

4. Conclusion

In this research, verification using various water-purifying filters was performed for the purpose of purifying the water polluted by radioactive iodine. As a result, the ion-exchange membrane showed high efficiency about the contaminated water purification to radioactive iodine. However, it seems that decontamination is dependent on activity concentration and the combination and decontamination efficiency of a filter must be considered. Although purification of contaminated water, such as a swim pool and a pond, was one of the purposes, it seemed that it is important to consider a jam of the filter by various sediments. When purifying a swim pool using the filter in this research, processing time requires about 6 hours. However, it is possible to raise a purification rate by combining various kinds of filters

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