10.53587/25792865-2023.9-127

JAPANESE EXPERIENCE IN INNOVATIONS APPLICATION IN FRAMES OF ENVIRONMENTAL CONTROL

Sugie M., Oikawa Y., Iida Y., Kaneko A.
Environmental Control Center Co., Ltd.
Tokyo, Japan

In the article, in the context of the performed research in Environmental Control Center Co., Ltd, the topic of the environment is touched upon. The history of the formation of the legislative base of ecological monitoring of the environment in Japan is briefly reviewed. Special attention is given to the generalized materials obtained in the framework of the performed research works related to the localization of the methodical approach for determining the content of hexavalent chromium in the environment and the development of an express method for measuring the concentration of asbestos fibers in atmospheric air. An analysis of scientific research is given for each of the listed topics. The article also presents views on the current state of the issue of preventing pollution of the marine environment with plastic. This direction of research is also supplemented by the presentation of national projects operating in Japan.

Keywords: *environmental protection, methodical approach, measurement method, hexavalent chromium, asbestos fibers, marine plastic, national projects.*

Environmental Control Center Co., Ltd. was established in Japan in 1971. During this period, Japan was experiencing serious environmental pollution problems, as there was no due attention to the solution of problems related to the protection of the environment. Recognizing the importance of having its own environmental policy, in order to prevent damage, primarily to the national environment, both in the short and long term, in Japan, the Basic Act on Pollution Control was adopted in 1967, and subsequently, in 1971 the Environment Agency was established. At the initial stage of the companyRs formation, within the framework of exploratory research to solve the identified environmental problems, studies were carried out on environmental monitoring of water, air and soil. In the process of implementing ecological monitoring of the environment, the company also studied the physical and chemical characteristics of wastewater and exhaust gases generated during the operation of industrial enterprises and vehicles. In subsequent phases of research activities, the company also developed solutions to problems related to noise, vibration, odors, known as sensory pollution. Later, as environmental issues diversified, studies were carried out on the analysis of dioxins and POPs, asbestos, radioactivity and other substances, and new methodological approaches were developed for the analysis of chemicals. Along with the above, the company began to provide consulting services related to the collection of environmental data, planning and implementation of JapanRs national environmental policy. Today Environmental Control

Correspondence address: Sugie Masashi, PhD, Technical manager of technical headquarters Environmental Control Center Co, .Ltd .,Japan, Tokyo, Hahioji city, Shimo-ongata-machi 323-1, msugie@kankyo-kanri.co.jp

Center Co., Ltd.. is a comprehensive environmental consulting firm with about 300 employees, five think tanks and a test farm in Japan. The current achieved reality of the company gives grounds to state that at the moment Environmental Control Center Co., Ltd.. is able to solve various environmental problems.

In order to understand and interpret the results of exploratory scientific work previously performed by the Environmental Control Center Co., Ltd. In this article, we will consider the following two studies and one topic:

I. Localization of the methodological approach to determine the content of hexavalent chromium in the ambient air. Hexavalent chromium compounds were identified in 2011 by Japan Rs Air Pollution Control Law as a substance that is considered to have a certain degree of high risk to health. Chromium exists in the environment primarily in the form of "trivalent chromium" or "hexavalent chromium". However, since no method has been established to separate the two, the evaluation of hexavalent chromium was done by measuring total chromium. A composition analysis method for chromium has been developed that combines ion chromatography or liquid chromatography with an ICP mass spectrometry system. In 2017, this method was adopted by the Ministry of the Environment of Japan as a method designed for this purpose. Further, according to the text of the article, the results of approbation in the Environmental Control Center Co., Ltd of the mentioned method, accepted for use by the Ministry of the Environment of Japan, will be presented.

II Development of a high-precision express method for measuring the concentration of fibers in the atmospheric air using artificial intelligence and scanning electron microscopy. This study was carried out with the aim of developing a measurement method that allows high- speed counting of thin fibers that cannot be observed using conventional phase contrast microscopy, but can be measured using a scanning electron microscope equipped with an artificial intelligence image recognition system.

III. The introduction of countermeasures against marine plastic pollution in Global and Japan.

This report provides an overview of the current state of marine plastic pollution control and international efforts. This topic is based on work performed by our engineers on secondment to the Ministry of Environment.

Let's take a closer look at each of the above two studies prformed at the Environmental Control Center Co., Ltd. in more detail.

I. Analytical studies for the determination of hexavalent chromium in ambient air.

Chromium (Cr) is used in large quantities in various industries because of its high resistance to corrosion, heat, and wear. Chromium is emitted in nature from human induced souses, and generally exists in two oxidation states: trivalent chromium Cr(III) and hexavalent chromium Cr(VI). Cr(III) is only toxic at high concentrations and is even essential to some aquatic organisms or humans for some metabolisms. On the other hand, Cr(VI) is a strong oxidizer and highly toxic at the ppb level. For human beings, Cr(VI) is carcinogenic, especially for our lungs, noses, and nasal sinuses. Therefore, the Japanese Government made regulations regarding Cr(VI), such as

Environmental Quality Standards or Soil Contamination Countermeasures Act. In view of this circumstance, the Government of Japan has passed a number of regulations regarding Cr(VI), including such as Environmental Quality Standards and Law on Measures to Combat Pollution of Soil. Unfortunately, however, there are no regulations or standards for airborne Cr(VI) in Japan. In 2018, the average concentration of total chromium in ambient air in Japan was 3.8 ng/m3, which exceeds the US Environmental Protection Agency (EPA) airborne Cr(VI) risk level. Taking this situation into account, the Ministry of the Environment of Japan (MOE) has developed Guidelines for Hazardous Air Pollutant Analysis Methods for Determination of Cr(VI) in Ambient Air (Part 5, Chapter 4). In this regard, it is very important to determine the exact concentration of airborne Cr(VI), since its toxicity and carcinogenicity to humans are obvious. However, the accuracy of the determination of Cr(VI) in ambient air remains a problem because Cr(VI) is chemically unstable and tends to be reduced to Cr(III). Taking into account that the Environmental Control Center Co., Ltd does not have a method for determining airborne Cr(VI), the employees of the company, in accordance with the adopted method set out in the manual of the Ministry of the Environment, conducted experimental studies to gradually develop a number of the following procedures, such as pretreatment, formation conditions, analytical conditions for the determination of Cr(VI) in atmospheric air.

Below we consider the individual stages and parameters of the performed analytical studies:

a) procedure for making alkaline-impregnated filters

The filters used in the study were cellulose filters (1 μm, 47 mm, ADVANTEC). They were cleaned with a solution of 10% HNO_3 and 2% HF, then impregnated with 0.12 mol/L $NaHCO_3$. Impregnated filters were put into a desiccator until they dried up. The filters were wrapped in aluminum foil and stored in three conditions until use: in a freezer (-30℃), in a refrigerator (7℃), and at room temperature (25℃). The concentrations of Cr(VI) in stored filters were determined on days zero, one, two, five and seven to observe chromium morphology change depending on storage temperature.

b) elution and pre-treatment

Alkaline-impregnated filters were put into polypropylene tubes and extracted in an ultrasonic bath with 5 mL ultrapure water for 30 minutes. The extracted samples were filtered with disc filters (NY013045, Membrane Solutions).

c) production of standards and construction of a calibration curve

Standard solutions were prepared for making calibration curve in the range of 0-5 μg/L. All of the standard solutions were prepared with 5 mmol/L $NaCO_3$ solution to make the pH the same as the samples.

d) characteristics of Liquid Chromatography (LC) and Inductively Coupled Plasma Mass Spectrometer (ICP/MS).

To determine Cr(VI) concentration, LC/ICP/MS analysis method was used. The conditions of LC and ICP/MS are as described in Table 1 and Table 2.

Table. 1 Conditions of LC

Equipment	: 1260 Infinity II LC (Agilent Technologies)
Column	: Anion-exchange columns (Agilent Technologies)
Eluent	: 20 mmol/L ammonium nitrate + 20 mmol/L ammonia water
Flow	: 1.2 mL/min
Temperature	: 25°C
Injection Volume	: 100 µL

Table 2. Conditions of ICP/MS

Equipment	: ICP/MS 8800 (Agilent)
High-frequency output	: 1550W
m/z	: 52
Collision Mode	: He, 5 mL/min
Integration time	: 0.4 s

Discussion of the results of the analytical study.

- calculations of Limit of Detection (LOD) and Limit of Quantitation (LOQ)

To determine LOD and LQD, the standard solution that contains 0.1µ g/L of Cr(VI) was measured with LC/ICP/MS. The measurement was repeated five times, and the results were used to calculate the standard deviation (SD). Operation blank samples were measured with five times repetition as well. Table 3 shows the calculated results of the LOD and the LQD.

Both of the LOQs calculated from the 0.1 µg/L standard solution and the operation blank were below the target LOQ of 0.08 ng/m^3: one-tenth of EPARs risk level criterion of 0.8 ng/m.^{3}

Table. 3 Calculations of LOD and LQD

	Concentration of airborne Cr(VI) (ng/m^3)	
	0.1 g/L Cr(VI) standard solution	Operation blank
The average of five times measurement	0.0704	0.0213
SD (s)	0.0021	0.0045
LOD (3s)	0.0063	0.0136
LQD (10s)	0.0209	0.0453

- spike and recovery test in the pre treatment process. 200 µL of 50 µg/L standard solution of Cr(VI) (equals to 1.389 ng/m^3 of airborne Cr(VI) concentration) was spiked on alkaline-impregnated filters. As a result, 99.7 110.5 % of the spiked solution was collected. It could be said that there is no loss of Cr(VI) during the pretreatment process or contamination from

the instruments.

- study of stability of Cr(VI) in blank filters. Samples, prepared in accordance with paragraphs "a" and "b", were analyzed with LC/ICP/MS, then the results were converted to the concentration in ambient air. The collected air volume which was used in the calculation was 7.2 m^3. Figure 1 shows the transition of Cr(VI) concentration. According to this result, it is thought that the most preferable condition to store the alkaline-impregnated filters is frozen since the concentration of Cr(VI) did not change relatively between day 0 and day-7, this result suggests that very little reduction of Cr(III) occurred. On the other hand, lots of Cr(III) changed to Cr(VI) in the filters which were stored at room temperature.

Thus, it should be noted, the prepared alkaline-impregnated filters should be stored under freezing condition until use, and should be used no later than seven days after preparation.

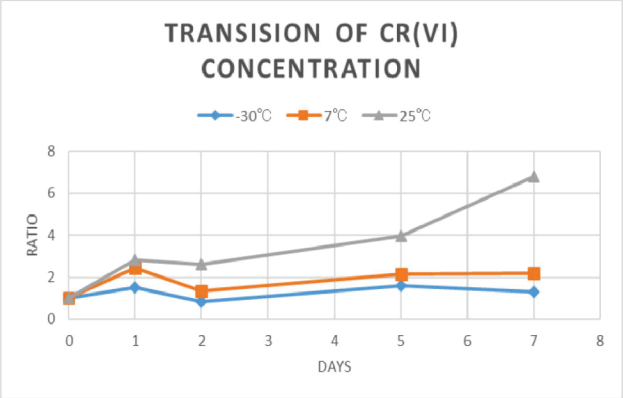

Figure 1. Transitions of Cr(VI) concentrations in blank filters (Cr(VI)concentrations of Day-0 was set as 1)

To keep alkaline-impregnated filters under frozen conditions until use is the key to preventing chromium from morphological change. Since this consideration did not include the method of sampling air in practice, it is necessary to establish a flow of an analytical method of airborne Cr(VI) starting from making alkaline-impregnated filters, sampling air, transporting the filters, and analyzing with LC/ICP/MS.

II. Development of rapid and highly accurate method to measu re concentration of fibers in atmosphere using artificial intelligence and scanning electron microscopy.

The aim of this study was to develop a measurement method that would quickly enumerate asbestos fibers using scanning electron microscopy equipped with an artificial intelligence image recognition system (AI-SEM), detecting thin fibers that cannot be observed using the conventional phase contrast method. microscopy (PCM). A simulated fiber sampling filter in air was constructed using chrysotile (white asbestos) with water filtration. A total of 108 images was taken of the samples at a 5 kV accelerating voltage with 10 000X magnification scanning electron microscopy (SEM). Each of three expert analysts counted 108 images and created a model answer for fibers. We trained the artificial intelligence (AI) using 25 of the 108 images. After the training, the AI counted fibers in 108 images again. Based on the results of the research, the following results were obtained.

12.1% difference between the AI counting results and the model answer. At 10 000X magnification, AI-SEM can detect 87.9% of fibers with a diameter of 0.06-3 μm, which is similar to a skilled analyst. Fibers with a diameter of 0.2 μm or less cannot be confirmed by phase-contrast microscopy (PCM). When observing the same area on 300 images at 1500X SEM magnification- as specified in the Asbestos Monitoring Guidelines recommended for implementation by the Ministry of the Environment of Japan - with 10 000X SEM, the expected analysis time required for the trained AI is 5 h, whereas the expected time required for observation by an analyst is 251 h. Thus, the developed AI-SEM method allows counting thin fibers with greater accuracy and faster than conventional PCM and SEM methods.

The full text of this study is available at https://doi.org/10.1002/1348 -9585.12238 .

III. The introduction of countermeasures against marine plastic pollution in Global and Japan.

Separately, in this article I would also like to briefly outline the current state of development of the issue of preventing plastic pollution of the marine environment, as well as the ongoing efforts of the international community to find ways to resolve this problem. It is no secret that microplastic pollution of the marine environment is one of the main environmental problems in the world community. The information presented in this article is the result of joint preparatory work with the Ministry of the Environment of Japan aimed at understanding the policy related to resolving the problem of marine plastic pollution.

Analyzing the steps taken to find solutions at the global level, the following should be noted. In 2016, Eunomia which is an independent consultancy in EU estimated the amount of plastic flowing into sea. In the result, it is estimated total amount of plastic is 12.2million tons per annual and 9 million tons per annual of them is land-based litters (Fig.2).

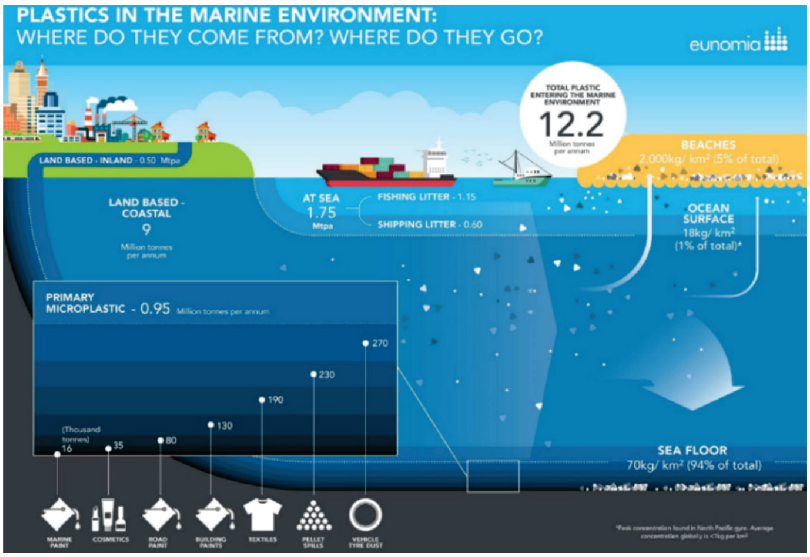

Fig 2. Annual amount of plastic entering environment
(Eunomia, 2016, Plastics in the Marine Environment)

Therefore, marine plastic pollution problem is not only for countries having coastline but also for landlocked countries.

In 2019, the G20 meeting was held in Osaka (Japan). The G20 leaders shared the Osaka Blue Ocean Vision vision. As of April 2023, more than 87 countries and regions share this vision, in addition to G20 members. The main body of this vision is: We aim to reduce additional marine plastic pollution to zero by 2050. This vision is based on the implementation structure of the G20. In addition, an international legally binding document on plastic pollution was discussed, which is planned to be adopted within the next 3 years. At the end of the G20 Summit in Osaka, the Government of Japan launched a program called "Marine Initiative" to promote effective action against marine litter, including the following 4 points: 1. Waste management, 2. Marine litter recovery, 3. Innovation, 4. Empowerment. Japan committed to supporting the empowerment of developing countries to promote waste management, marine litter recycling and innovation, mainly through policy measures.

At the same time, a marine plastic litter strategy was developed in Japan in order to realize the RROsaka Blue Ocean VisionRR mentioned above. The strategy includes a "National Action Plan on Marine Plastic Litter" with 8 points as promotion of proper waste management system, collection of plastic trash in the oceans, international cooperation with developing countries, exchange of best practices, etc.

It should be emphasized that a number of top-priority national projects are being simultaneously implemented in Japan at the moment. In particular,

1. Local Blue Ocean Vision (LBOV).

The Ministry of the Environment of Japan (MOEJ) has launched the Blue Ocean Local Vision (LBOV) project from 2021.Outline of the LBOV is that local governments, in cooperation with companies, formulate policy measures against marine litters, develop new business models with experts, and monitor their impacts with their expertise.

2) Plastic smart campaign

In Japan, Plastic smart campaign for wise use of plastics has been launches and required stakeholders to work voluntarily on the production of unnecessary single-use plastics, and the development and use of alternatives, and publicizing such action nationwide through social media and other means. Almost 3200 cases are registered as of April 2023 and you can see all cases at official website.

3) Guideline for River Microplastic Monitoring Method.

In 2023, MOEJ published Guideline for River Microplastic Monitoring Method. provides explanations and recommendations on how to collect microplastics (plastics less than 5 mm in diameter) in rivers and on the surface, building on the evidence-based evidence already available.

And in conclusion, it should be emphasized that considering, in the context of the scientific and practical mutually beneficial cooperation established since 2015 between the Environmental Control Center Co., Ltd. and the National Bureau of Expertises of the Republic of Armenia, numerous previously completed and currently being implemented in the Environmental Control Center Co., Ltd. scientific research, by publishing this article in the RRArmenian Journal of Forensic Expertise and Criminalistics, we confirm our focus on deepening scientific and methodological cooperation

between the experts of our organizations and plan to start forming the proper prerequisites that will allow in the near future to prepare and implement a joint research project.

References

1. The manual of methods for analyzing hazardous air pollutants, Ministry of Environment Japan: Part 5, Chapter 4.
2. Hayashi, Shoji, Sato (2021). Examination of Analysis Conditions for Hexavalent Chromium Compounds in Atmospheric Dust and Results of Additive Recovery Tests. in *Journal of Environmental Laboratories Association Vol.46 No.1*, 5-9.
3. Okuno, Nishimura (2020). Measurement Results of Hexavalent Chromium Compounds in Atmospheric Dust and Factors of Measurement Error. in *Journal of Environmental Laboratories Association Vol.45 No.2*, 63-67.
4. Sugimoto, Yoshida, Yamamoto, Nakanishi (2019). Survey of Hexavalent Chromium in Atmospheric Dust in Nara Prefecture. in *Nara Prefectural Center for Landscape and Environment Research Report No. 7*, 27-30.

ՇՐՋԱԿԱ ՄԻՋԱՎԱՅՐԻ ՊԱՀՊԱՆՈՒԹՅԱՆ ՈԼՈՐՏՈՒՄ ՆՈՐԱՐԱՐՈՒԹՅՈՒՆՆԵՐԻ ԿԻՐԱՌՄԱՆ ՃԱՊՈՆԱԿԱՆ ՓՈՐՁԸ

Սուգիե Մ., Օիկավա Յ., Իիդա Յ., Կանեկո Ա.

Հոդվածում, Ճապոնիայի շրջակա միջավայրի վերահսկման կենտրոնում կատարված հետազոտությունների համատեքստում, ներկայացվում է շրջակա միջավայրի պահպանության թեման: Համառոտ դիտարկվում է Ճապոնիայում շրջակա միջավայրի մոնիտորինգի օրենսդրական դաշտի ձևավորման պատմությունը: Առանձնահատուկ ուշադրություն է դարձվում կատարված որոնողական գիտական աշխատանքների շրջանակում ստացված ընդհանրացված նյութերին՝ կապված շրջակա միջավայրում վեցավալենտ քրոմի պարունակության որոշման մեթոդաբանական մոտեցման տեղայնացման և մթնոլորտային օդում ասբեստի մանրաթելերի կոնցենտրացիայի չափման էքսպրես մեթոդի մշակման հետ: Նշված թեմաներից յուրաքանչյուրի համար տրվում է գիտական հետազոտությունների վերլուծություն: Հոդվածում ներկայացվում են նաև ներկայումս ծովային միջավայրի պլաստիկ աղտոտման կանխարգելման վերաբերյալ տեսակետները: Հետազոտության այս ուղղությունը լրացվում է նաև Ճապոնիայում ընթացիկ ազգային նախագծերի ներկայացմամբ:

Բանալի բառեր. *շրջակա միջավայրի պաշտպանություն, մեթոդական մոտեցում, չափման մեթոդ, վեցավալենտ քրոմ, ասբեստի մանրաթելեր, ծովային պլաստիկ, ազգային նախագծեր:*

ЯПОНСКИЙ ОПЫТ ПРИМЕНЕНИЯ ИННОВАЦИЙ В ОБЛАСТИ ОХРАНЫ ОКРУЖАЮЩЕЙ СРЕДЫ

Сугие М., Ойкава Ю., Йида Ю., Канеко А.

В статье, в контексте выполненных в Environmental Control Center Co., Ltd. исследований, затрагивается тема охраны окружающей среды. Кратко рассматривается история формирование в Японии законодательной базы экологического мониторинга окружающей среды. Особое внимание в статье уделено обобщенным материалам полученным в рамках выполненых поисковых научных работ относящихся к локализации методического подхода по определению содержания шестивалентного хрома в окружающей среде и разработке экспресс метода измерения концентрации волокон асбеста в атмосферном воздухе. По каждый из перечисленных тем дан анализ научных изысканий. В статье также излагаются взгляды на текущее состояние вопроса по предотвращению загрязнения морской среды пластиком. Данное направление исследования дополнено также изложением действующих в Японии национальных проектов.

Ключевые слова: *охраны окружающей среды, методический подход, метод измерения, шестивалентный хром, волокно асбеста, морской пластик, национальные проекты.*

The article was submitted: 09.01.2023
The article was accepted: 01.06.2023