Laboratory Radioactive Protection and Safety Management

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Abstract. In order to strengthen the safety management of radioactive laboratories, ensure the safety of laboratory radioactive protection and management, this paper, according to the relevant national laws and regulations, combined with the characteristics and commitment of radioactive laboratories, analyzed the existing hazards, the protection and management measures that should be taken during radioactivity laboratories or in radioactive practice. Adhere to the principle of "prevention in the first place and integrating prevention with control" to ensure radiation safety, and environmental pollution.

1. Introduction
In 2010, the school became independent as the Environmental Protection and Safety Engineering which later adopted the present name of Environmental and Safety Engineering, existing environmental engineering, safety engineering (nuclear safety direction), environmental equipment engineering, 3 undergraduate majors.

After years of effort, the school is a mosaic of 4 nuclear features distinct regions:

(1) The nuclear facilities emergency safety technology and equipment: the main research content is to optimize the structural of nuclear emergency safety equipment and related safety operations technology;

(2) Airborne pollution control theory and techniques: the major studying contents are as follows: Theory and Technology of radon ventilation and radiation protection in uranium mines; Ventilation and Pneumatic Conveying Technology in the dynamic airflow environment of tall buildings.

(3) The management of decommissioning uranium tailings impoundments: The research contents are as follows: Treatment Technology of Uranium Tailings Dam, Risk and Consequence Evaluation Technology of Uranium Tailings Dam.

(4) The radioactive waste treatment: The research direction involves the treatment and disposal of radioactive wastes; the radioactive contamination prediction, assessment, and protection technology;

The lab have took charge of a great amount of radioactive technological development projects for our school, including the National Science Foundation, many provincial level projects. This paper analyzed the existing hazards, the protection and management measures that should be taken during radioactivity laboratories or in radioactive practice in order to ensure radiation safety, and avoid environmental pollution.
2. Characteristics of radionuclide
The radioactive material has not only the general properties of ordinary materials, but also the radioactivity characteristics, physical half-life, and radiochemistry [1-3]. When radioactive practice or during the course of the radioactivity experiment, there will be a lot of radioactive waste, the researchers are likely to be radiation damaged by radioactive rays [4]. It will influence the normal work of lab and create severe pollution if the rad- materials or wastes is not disposed suitably.

The process by which an atom changes from an unstable state to a more stable state by emitting radiation is called radioactive decay or radioactivity. The radioactive materials can spontaneously emit a stream of α, β particles or γ-rays in frequently decay [5-6]. So far, there are about 2,600 nuclides, 280 of them are stable nuclides which belong to 81 kinds of elements, and more than 2,300 radio nuclides. The common of nuclide used in the lab of Environmental Protection and Safety Engineering are shown in table 1[7-8].

| Items          | No. | 1     | 2     | 3     | 4     | 5     | 6     |
|----------------|-----|-------|-------|-------|-------|-------|-------|
| Radionuclides  |     | ²³⁸U  | ²²⁶Ra | ²³²Th | ⁴⁰K   | ¹⁴C   | ³²P   |
| Half-life      |     | 4.5*10⁹a | 1602a | (1.41±0.01)*10¹⁰a | (1.277±0.008)*10⁹a | 5720 a | 14.28 d |
| Main rays      |     | α,γ   | γ     | γ     | β,γ   | β     | β     |

3. The way of possible hazards from radioactive experiment
Researchers are received external irradiation from gamma rays and beta rays in the preparation process of radioactive isotopes samples and radioisotope tagging [9]. Unsealed radioactive source used in the experiments can spread easily. Walls, floors, equipment, countertop in the laboratory and work clothes, even skin surface of experimenter are moderately contaminated by volatile radionuclides that spills and overfills [10-12]. External irradiation is appeared when it is contaminated by surface pollutants in genera. The skin of human not only suffers external beam irradiation but enter the body through skin absorption or breathing and conjunctiva of the lab staff once the surface of human skin becomes radio-contamination [13]. In addition, unsealed radioactive source is easily leads to radioactive air pollution in the workplace through evaporation and volatilization.

4. Radiation protections

4.1. Protective measures for workers
(1) Use appropriate shielding to blocks radiation. Different rays have different requirements for shielding. The ray of α with heavy particles and slow characteristics can be blocked with a piece of paper. The β-ray is stopped by organic glass. But γ-ray is required to use concrete or lead brick to shield.

(2) Increase distance between the operations staff with radioactive sources. The more distance between operations staff and the source of the radiation, the less radiation operations staff will receive.

(3) Protective equipment such as gloves, gowns, masks and protective eyewear that made of lead should be worn according to the types and dosage of nuclide emitted the radial while operating. We can track the radiation exposure dose in real-time by personal dose meter.

4.2. Personnel training
The staff members and operators that engaged in radioactive work in long-term or short-term should accept vocational prevention and protection training before taking their posts. Each operations staff shall have mastered the properties of nuclide that they use, protection principles for radiation, the treatment and disposal of radioactive wastes before taking.
5. Safety managements of radiation laboratories

5.1. Establish and improve laboratory rules and regulations
To implement safety management system is the key to reduce radiological incidents. The safe and orderly operation of the laboratory not only depends on the establishment of every management policy, but also rest upon the manager and user of the laboratory observe the working regulation. The school authorities lay down some rules and regulations for all the manager and experimenter when they have performed experiments, such as Regulations on the management of radioactive laboratory, Radioactive Laboratory Safety rules, Radioactive laboratory operation procedures, Radioactive waste disposal method, Measures for the Prevention and Control of Radioactive Contamination, The use institution of laboratory instruments.

5.2. Strengthen leadership, carry out responsibility
The Institute has set up the Leading Group for Radiation Safety to strengthen the work of radiation safety and protection. The president served as the heads, deputy head of the Leading Group is lab director, and the group members are consists of each lab managers. The security management responsibilities of each room of the lab must be distributed among the people to strengthen responsibility consciousness [14-15].

5.3. Strict management on radioactive waste
The common radioactive waste have: 1) Experimental material that was besmirched with radionuclides in the course of the experiment, like absorbent paper, filter paper, filter membrane, gloves, plastic tips, culture plates, petri dishes, empty isotope bottles, syringes, etc. 2) the liquid produced during the experiment, such as cell supernatant, eluent and scintillation cocktail[16]. Experimental studies exert a large quantity of radioactive waste, but at the same time bring forth some non-radioactive waste. We required that two types of waste have been careful to distinguish handled. The hot waste does not discard into general trash can or empty into drains. We have to control or reduce the amount of radioactive waste, and achieve scientific rigour in operation of the experiment. Radioactive crap must be collected by classification and be separately disposed [17]. Containers for radioactive waste must meet a specific requirement of shielding and anti-leakage. The Container is properly labeled for the nuclide's name and characteristics.

5.4. Strengthen the monitoring of radioactivity levels in lab
We need to emphasis on the monitoring of radioisotope laboratories, and know the levels of radiation in real time to provide evidence for take protective measures.

The safety of radioactive laboratories is not only related to the normal operating of the school teaching and scientific research activities, but also relate to teachers and students' healthy security[18-20]. Therefore, to prevent accidents, must carries out the policy of putting prevention first and combining prevention with control in managing existing. We will adhere to strict management and safety-first attitude, and creating a positive climate for teaching and research of university.

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References

[1] Zhang Zhiqiang, Liu Xuelei, Li Enjing, He Ping. Exploration and practice of laboratory safety management in Peking University [J/OL]. Experimental Technology and Management, 2017, (10): 244-248.

[2] Huang Yaoyao, Huang Hanhuang, Shi Runping. Research Progress of Radioactive Wastewater Treatment Technology [J/OL]. Applied Chemical Industry, 2018, 47 (01): 185-189.

[3] Wu Songliang. The Management of Radiopharmaceuticals Laboratory [J]. Science and technology economy, 2016, (26): 99.

[4] Wang Ju. Geological disposal of high level radioactive waste: Key scientific issues and progress in China [J]. science and technology review, 2016, 34 (15): 51-55.

[5] Diao Ying. Discussion on the safety management of biological laboratory [J]. Technology Outlook, 2014, (23): 117.

[6] Ma Jianzhong, Shan Li, Lu Jinyin, Yin Huying. Exploration on safety management of radiocative isotopr and source in laboratory [J]. Experimental Technology and Management, 2014, 31 (10): 226-228+245.

[7] Yu Guan-xia, Wu Lin-gen. Analyses of Safety and Environmental Protection in the College Laboratory [J]. Research and Exploration in Laboratory, 2014, 33 (09): 296-300.

[8] An Quan, Zhang Wei, Qin Xiujuan, Li Weibing, Wen Jianhua. Prevention and management of radioactive drug safety evaluation laboratory [J].Carcinogenesis, Teratogenesis &Mutagenesis, 2014, 26 (02): 154-156.

[9] Wang Liangyan, Hong qihua, Hua Yuejin. Some thoughts on laboratory safety management for radioactive isotopes [J]. Experimental Technology and management, 2013, 30 (12): 190-192.

[10] Li Enjing, He Ping, Zhang ZhiQiang. Whole-process Supervision of Radioisotopes and Radiation Generators at Peking University [J]. Radiation Protection Bulletin, 2013, 33 (06): 27-30.

[11] Wang Dahai. Management of Radioactive Isotopes and Apparatus in University Laboratories. [J]. Research and Exploration in Laboratory,2013,32(06):231-234.

[12] Wang Jianguo. Preliminary Exploration on radio activity level investigation and radiation safety Management of a Laboratory [J]. Chinese Journal of Radiological Health, 2012, 21 (03): 316-317.

[13] Zheng Xianli, Xie Juying, Zhao Yue, Xia Yanfang, Zhang Boli, Dong Xiaotao. Analysis of the total radioactivity activity of α, β rays in vegetables that grow in the garden beside a Laboratory [J]. Chinese Journal of Radiological Health,2011, 20 (02): 179-180.

[14] Ning Pin, Xu Yujie, Zhang Youjiu, Zhang Baoguo, Cao Jianping, Hu Mingjiang, Wang Daojin, Zhu Caiying. Safety management of radioactive laboratories [J]. Chinese Journal of Radiological Health,2011, 20 (02): 217-218.

[15] Wu Jialong, Sun Wei, Wang Yun, Bai Guoding. Comparison of National Radionuclide γ Spectrometric Analysis Methods in 2009[J]. Chinese Journal of Health Laboratory Technology, 2010, 20 (12): 3483-3484.

[16] Sun Hongyun, Li Zhigang. Analysis on the Safety Management of Laboratory [J]. China quality and technical supervision, 2009, (05): 58-59.

[17] Zhan Yongjia, Yu Xiumin, Tong Qinwei. Current situation and problems on laboratory safety management in universities [J]. China Modern Educational Equipment, 2009, (01): 117-119.

[18] Dong Junjun, Liu Yun, Geng Xiaohong.Enhancing the safety management of radiation Lab [J].Experimental Technology and Management, 2009,01): 117-119.

[19] NPC Standing Committee concerned about laboratory safety to ensure public health [J]. China Modern Educational Equipment,2004, 07): 60-72.

[20] Xu Jige, Li Jianmin. The safety management of radioisotope laboratory [J]. China Modern Educational Equipment,2003, (09): 19-21.