Impact of residual radioactivity associated with NORMs in the water supply cycle

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INTRODUCTION

Water treatment processes purify drinking water by removing naturally occurring radioactive materials (NORM) present in raw water supplies. As large quantities of water are treated using a filtration process, the NORMs (mostly uranium and radium) become concentrated in various filtration media, and in wastes streams as well, which require management and disposal options, as regulated by the European Directive 2013/51/EURATOM.

Drinking water systems should protect the public from exposure to excessive levels of radionuclides in drinking water, and workers from exposure to radioactive wastes generated by the treatment processes.

The accumulation mechanisms, the effects of NORMs (e.g., radon exposure and external radiation) and the consequent radiological risk for workers in the water facilities and/or filter-waste disposal sites are, however, rarely studied.

PURPOSE

The main goal of this work is to understand the nature and potential for the impact of the residual radioactivity associated with NORM in the water supply cycle (treatment, maintenance, transport and disposal).

It is proposed to develop a predictive model of the potential concentrations of radionuclide in residuals and filters at the system, considering the type of treatment and based on the contaminants mass balances in the sludge and other residuals (radionuclides concentration, the volume of waste streams and finished water).

The next step is to perform the dose estimation and quantitative risk assessment (occupational, public, environment) in maintenance and cleaning activities and handling, storage, and disposal operations.

The final goal is to extend the model to other facilities in a case by case approach.

METHODS and MATERIALS

1. Characterization of the water treatment plant, including layout complexity (Fig. 1) and geographical location (geologic setting or lithology):
   - Treatment processes and;
   - Effectiveness on radionuclides removal;

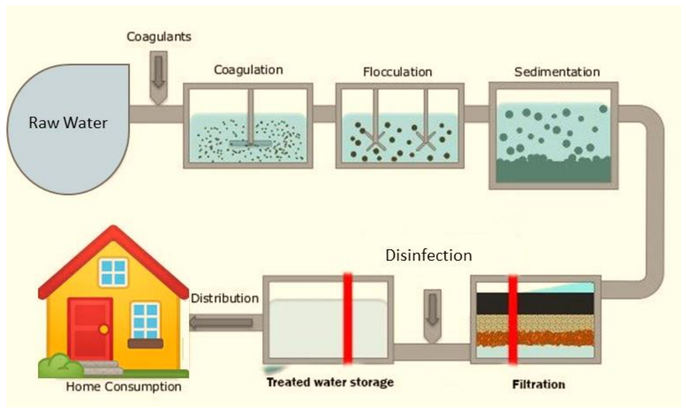

Fig. 1: Generic steps of water purification process [1].

2. Sampling and characterization of the ingoing (raw water) and outgoing water (drinking water);
3. Sampling and characterization of waste streams (volume, activity, flow rates, etc.): **i)** solid residuals (spent: resins, filter media, membranes, and sludge); **ii)** liquid residuals (brines, backwash water, rinse water, acid neutralization streams, concentrates);
4. Development of a predictive model of the potential concentrations of radioactivity in residuals and filters at the system (estimate radionuclides concentration, volume of waste streams and finished water);
5. Dose estimation and quantitative risk assessment (occupational, public, environment) in maintenance and cleaning activities and in handling, storage, and disposal operations:
   - Tasks undertaken in water treatment works;
   - Calculation of doses for the identified generic tasks;
   - Potential radiation exposure pathways (Fig. 2);
   - Overall doses for all relevant exposure pathways,

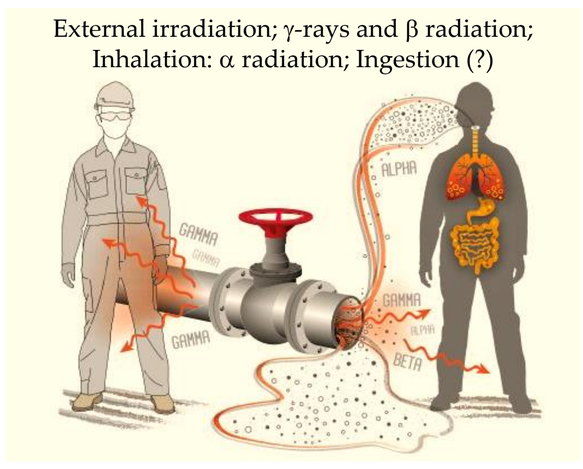

Fig. 2: Potential exposure pathways [2].

6. Extend the model to other facilities in a case by case approach;
7. Test treatment technology (target - waste and sludge's radionuclides concentration issues).

EXPECTED OUTCOMES

- Knowledge on the radioactivity content in filtering materials and other by-products routinely generated in water extraction and purification process, which is scarce worldwide;
- Application of the predictive model for the potential concentrations of radioactivity in residuals and filters at the treatment system to other facilities;
- Integrated model for the assessment and mitigation of the impact of residual radioactivity associated with the water supply cycle;
- Identification and development of treatment methods (simple, combined) for the removal of residual radioactivity associated with the water supply cycle.

PRELIMINARY RESULTS

- Potential real scenario - a case study;
- Identified tasks aggregated into 'generic' tasks as groups of tasks comparable regardless of radiation exposure [3]:
  - (1) General maintenance and inspection;
  - (2) Inspection of back-washing of filter beds;
  - (3) Maintenance of dissolved air floatation units;
  - (4) Filter bed maintenance;
  - (5) Cleaning settling tanks;
  - (6) Transporting sludge;
  - (7) Working with processed sludge;
  - (8) Operating sludge press;
  - (9) Maintenance: membrane, reverse osmosis, ion exchange units.
- Allows to evaluate the radiation exposures of workers in any drinking water treatment facility.
- Identified associated exposure pathways [3]:
  - (1) External γ;
  - (2) External (γ and β), inhalation of resuspended spray and filter media;
  - (3) External (γ and β);
  - (4) External (γ and β), inhalation in dry conditions or if windy outdoors or if hosing;
  - (5) External (γ and β), inhalation in dry conditions or if windy outdoors or if hosing;
  - (6) External γ (outdoor in vehicle);
  - (7) External (γ and β), ingestion via hands, inhalation if sludge is air dried in bunkers or lagoons;
  - (8) External (γ and β), ingestion via hands, inhalation via enhanced resuspension if dry or using pressure hose;
  - (9) External (γ and β).
- Data collection/determination - ongoing:
  - Activity concentration of the contaminated material;
  - Length of time and frequency of exposure to the contaminated material;
  - Dose factors - radiation dose per unit of activity concentration for each generic task for each exposure pathway per hour of exposure, in a specific exposure situation.
  - Calculation of doses for the identified generic tasks;
    - External doses from γ-ray emitting radionuclides;
    - Inadvertent ingestion;
    - Inhalation (particles and indoor radon);
    - External dose from β emitting radionuclides;
  - Overall doses for all relevant exposure pathways.

CONCLUSIONS

- This work is under development, however, calculated doses will be used to identify the relevant task in terms of exposure for a given facility and the significant exposure pathways for each generic task.
- Water treatment facilities is one of the industrial sectors involving naturally-occurring radioactive material. Therefore, it is necessary to conduct a radiation safety assessment.
- A new treatment process will be tested in the raw water based on a photocatalytic/catalytic system with porous microspheres [4].

ACKOWLEDGMENTS

This work was financially supported by Base Funding - UIDB/04028/2020 and Programmatic Funding - UIDP/04028/2020 of the Research Center for Natural Resources and Environment – CERENA - funded by national funds through the FCT/MCTES (PIDDAC).

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