Risk of radiation exposure of the lens of the eye for members of the public
Bibliography study

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Objectives of this literature review

New dose limit recommended by ICRP for the lens of the eye for occupational exposure : $$
\frac{1}{2}$$ to 20 mSv per year [1]

No explicit recommendation regarding the dose limit for the public

Are there potential situations where public exposure can lead to equivalent doses to the lens of the eye exceeding 1 mSv per year?

Methodology

Three steps :
1/ Exhaustive list of consumer goods containing radioactive substances [2] [3]
2/ Focus on goods that may lead to significant eye lens exposure
3/ IRSN calculations of dose to the lens of the eye using when necessary MCRPX code [5]

Situations for workers and patients are not considered in the scope of this study

Weapon sights

Tritium used to illuminate the aiming triangle in the night
Not widely spread, concerns only specialists
Radionuclides: tritium (up to 10 Gbq)

Photographic films

Old photographic prints, developed using uranium nitrate
Exotic situation
Radionuclides: uranium

TV receivers and PC monitors

Television receivers or PC monitors with cathode-ray tubes
Essentially television manufactured before 1970
X-rays (up to 5.3 µSv h⁻¹ averaged over 10 cm at any readily accessible point 5 cm from the surface)

No risk of significant radiation exposure to the eye lens

Timepieces

Radioluminescent paint added to timepieces
Not widely spread, concerns only amateur repairers timepieces
Radionuclides: radium-226 (170 kBq maximum), tritium or promethium-147

- 0.25 mSv per year
- Not significant

Limited or even insignificant radiation exposure to the eye lens

Naturally radioactive minerals

Concerns only amateur collecting radioactive minerals
Radionuclides: uranium, thorium, Radium-226

- 0.85 mSv per year
- For photon radiations only
- 0.01 mSv per year (if 1 ppm of Ra)

Complete calculation in progress

Significant exposure for some minerals, but very rare situations

Dental ceramics with added uranium

Before the 1980’s, natural or depleted uranium was added in dental porcelains for aesthetic purpose (fluorescent properties)
Only few people may be concerned
Radionuclides: uranium (± 10 kBq g⁻¹), 4K

Dose to the eye lens induced by γ radiations only ± 0.1 mSv

No risk of significant radiation exposure to the eye lens

Dental products

New dental ceramics

Nowadays, only natural presence of potassium-40, rubidium-87, carbon and thorium (as impurities)

Radionuclides: uranium, thorium, Radium-226

Amounts of several orders of magnitude below former dental ceramics

Activities similar to the former dental ceramics

Gemstones

Two scenarii of exposure: gemstones in a piercing (0.02 carat, 3 cm from the eye) or in earrings (2x10 carat, 7 cm from the eye)

Naturally radioactive gemstones

Uranium, thorium and potassium-40 may be naturally present in some gemstones as zircon (widely used) or eukane, thorite,...

- Zircon: ± 7 µSv per year
- Other gemstones: up to 31 mSv per year (143 kBq of natural thorium in thorite)

Dose to the eye lens is not significant

Exotic situations

Irradiated gemstones

Some gemstones are irradiated to modify their colour
Most commonly irradiated gemstones: topaz also: tourmaline, zircon, beryl, quartz, diamonds...

Many activated elements due to the irradiation
- Si, Al, Fe, Mn, Cr, Ni, Cu, and thorium (as impurities)
- US release limits for each radionuclides

Dose is not significant

Concentrations at higher activity

Very rare situations

Lenses

Thorium occurs naturally in rare earths and zirconium oxides used to process the glass, or thorium is intentionally added to improve optical properties. It can also be used in surface coating.

Lenses in eyeglasses

500 kBq of natural thorium
Eyeglasses worn 16 hours per day, all the year
Dose rate: 0.3 mSv h⁻¹
1 mSv/yr is reached for activity - 1.3 kBq

Significant dose rate but the activity of thorium considered could not be confirmed

Lenses in cameras

500 kBq of natural thorium
Yawfinder of a camera, used 1 h per week, all the year
Dose rate: 2.8 µSv h⁻¹
1 mSv/yr is reached for activity - 7 kBq

Very rare situations

Conclusion

No current situation was identified where member of the public might receive significant radiation dose to the lens of the eye.

The very few existing situations where the dose to the lens of the eye could reach 1 mSv/yr are exotic ones:
- One significant exposure comes from ophthalmic lenses with 500 kBq of thorium. But this activity mentioned in the literature could not be confirmed and no information about the use of these items nor their quantity on the marketplace were available.
- The second situation comes from radioactive minerals that could be owned by mineral collectors, and especially radiolaritites. The highest concentration of radium-226 found in the bibliography could not be confirmed, and the only other values of concentrations found in the literature review are several orders of magnitude lower. In that case, there is no significant exposure to the lens of the eye anymore.

REFERENCES
1) International Commission on Radiological Protection, Statement on Tissue Reactions, approved by the Commission on April 21, 2001
4) M. A. Chevallier, A. Rannou, I. Clairand, C. Villagra, Risk of radiation exposure of the lens of the eye for members of the public, Bibliography study, IRSN report, FRA-HOM/SE n° 2010/00041
5) J.S. Hendricks et al., MCRPX 2.6.0 Extension, LA-UR-20-2164, April 2005