How Do We Compare Activity and Dose?

How Many Picocuries in a Chest X-Rays?

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For the purposes of radiation protection, it is not always useful to describe the potential hazard of a radioactive material in terms of its activity. For instance, 1 mCi of tritium a centimeter from the body poses a much different hazard than 1 mCi of phosphorus-32 a centimeter from the body.

Consequently, it is often prefe rable to measure radiation by describing the effect of that radiation on the materials through which it passes. The three main processes that describe the effect of radiation on a volume of material are:

Quantity	Unit	What is measured	Amount
Activity	Curie (Ci) Becquerel (Bq)	The number of decays per unit time	1 Ci = 1,000 mCi 1 Bq = 27 x 10^{-12} Ci
Absorbed Dose	Rad Gray (Gy)	Amount of energy absorbed in 1 gram of matter from radiation	1 rad = 1,000 mrad 1 Gy = 100 rad
Dose Equivalent	Rem Sievert (Sv)	Absorbed dose modified by the ability of the radiation to cause biological damage	rem = rad x Quality Factor 1 rem = 1,000 mrem 1 Sv = 100 rem

ACTIVITY

A spontaneous nuclear transformation is called radioactivity. Radioactivity is characterized by the emission of energy and/or mass from the nucleus of an atom. Thus, the fundamental property of radioactivity is an atom's ability to decay or change spontaneously by a nuclear transformation. When radioactivity decays an atom of one element it is transformed into an atom of another element. The spontaneous breakdown of a radioactive atom, with the discharge of alpha, beta, gamma, or X-ray radiation is called a disintegration. The number of disintegrations that occur in a given quantity of material during a specific period of time is called activity. The conventional unit of activity is the Curie (Ci), the international unit is the Becquerel (Bq). A Ci is equal to 37 billion disintegrations per second. The activity of a radioactive material can be easily calculated based on the half-life of the material and the mass of the material. Different masses of the same radioactive material have different activities.

ABSORBED DOSE

When radioactive material decays and the transformation of the atoms opccur there is characteristic energy that is released. This energy is released in the form of what we call radiation. There are different types of radiation, but they all serve the same general purpose, removing excess energy from the radioactive atom after it transforms. These radiations travel in the air until they "stop". Radiations stop by losing their energy. Radiation loses its energy by interacting with atoms in its pathway and transferring energy to the atom during these interactions. When an interaction with radiation removes an electron from the atom it is called ionization. Other types of interactions include the excitation of an atom, breaking molecular bonds, and the heating of an atom or molecule. Ionization, excitation and molecular bond breaking can cause biological damage; heat transfer does not necessarily cause biological damage. The energy deposited by a radiation in a given volume of material, i.e., tissue, is called the absorbed dose. The conventional unit for absorbed dose is the Rad, the international unit is called the Gray (Gy).

EQUIVALENT DOSE

The absorbed dose quantifies the amount of energy transferred to a volume of material, but it does not reflect the biological damage that potentially occurred. Because of the physics of radiation, the biological effect of the same amount of absorbed energy may vary according to the type of the radiation. A quality factor, Q was developed, to be able to compare doses from different radiation types. The absorbed dose times Q gives the equivalent dose. The conventional unit for dose equivalent is the Rem, the international unit is the Sievert (SV).

HOW MANY PICOCURIES IN A CHEST X-RAY?

Frequently this is how the news media presents radiological questions. It should be noted this is NOT a valid question as explained below.

A **PicoCurie (pCi)** is a unit of **activity**; it quantifies the number of disintegrations that occur during a specific period of time.

A **chest x-ray** is described in terms of **dose equivalent**, with units of Rem. The dose equivalent describes the biological effect of the energy absorbed per unit volume of mass from the radiation.

These two concepts are **not** readily comparable with the given information. The amount of energy deposited in a unit volume and the type of radiation emitted from the pCi of material are needed for a pCi to be comparable to a chest X-ray. This information is usually available, and computer codes are commonly used to aid in performing these complex calculations.

HOW BIG IS A PICOCURIE?

A *picocurie* is one trillionth of a curie. To put the relative size of one trillionth into perspective, consider that if the Earth were reduced to one trillionth of its diameter, the "picoEarth" would be smaller in diameter than a speck of dust. In fact, it would be six times smaller than the thickness of a human hair.

The difference between the curie and the picocurie is so vast that other metric units are used between them.

These are as follows:

- Millicurie (mCi) = 1/1,000 (one thousandth) of a curie
- Microcurie (μCi) = 1/1,000,000 (one millionth) of a curie
- Nanocurie (nCi) = 1/1,000,000,000 (one billionth) of a curie
- Picocurie (pCi) = 1/1,000,000,000,000 (one trillionth) of a curie

The following chart shows the relative differences between the units and gives analogies in dollars. It also gives examples of where these various amounts of

radioactivity could typically be found. The number of disintegrations per minute has been rounded off for the chart.

Unit of Radioactivity	Symbol	Disintegrations per Minute	Dollar Analogy	Examples of Rad. Materials
1 Curie	Ci	2 Trillion	2 times the annual federal budget	Nuclear Medicine Generator
1 Millicurie	mCi	2 Billion	Cost of new inter-state highway from Atlanta to San Francisco	Amount used in a brain or liver scan
1 Microcurie	μCi	2 Million	All-star baseball player's salary	Amount used in thyroid tests
1 Nanocurie	nCi	2 Thousand	Annual home energy costs	Consumer products
1 Picocurie	PCi	2	Cost of a hamburger and coke	Background environmental levels

Source

Formerly Utilized Sites Remedial Action Program (FUSRAP)
http://www.lrb.usace.army.mil/fusrap/docs/fusrap-fs-picocurie.pdf

Links to external resources are provided as a public service and do not imply endorsement by the Washington State Department of Health.