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Original Article

Proposing a Simple Radiation Scale for the Public: Radiation Index

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ABSTRACT

A new radiation scale is proposed. With empathy toward the vast majority of people who are not well versed in radiation and related matters, and thus suffering from misunderstanding that breeds unnecessary fear of radiation, the aim of proposing a new radiation scale, *radiation index* (RAIN), is to put the general public at ease with the concept of radiation. RAIN is defined in dimensionless numbers that relate any specific radiation dose to a properly defined reference level. As RAIN is expressed in plain numbers without an attached scientific unit, the public will feel comfortable with its friendly look, which in turn should help them understand radiation dose levels easily and allay their anxieties about radiation. The expanded awareness and proper understanding of radiation will empower the public to feel that they are not hopeless victims of radiation. The correspondence between RAIN and the specific accumulated dose is established. The equivalence will allow RAIN to serve as a common language of communication for the general public with which they can converse with radiation experts to discuss matters related to radiation safety, radiation diagnosis and therapy, nuclear accidents, and other related matters. Such fruitful dialogues will ultimately enhance public acceptance of radiation and associated technologies.

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1. Introduction

Radiation remains a mysterious concept to a vast majority of people except for a tiny minority of experts who either specialize in it or work with it in their occupation. This misunderstanding breeds unnecessary fear of radiation. Muller [1] attempts to put radiation in proper perspective by giving some interesting examples of radioactive materials: books are radioactive; our body is radioactive (unless long dead); the United States Bureau of Alcohol, Tobacco, and

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Firearms requires that wine, gin, whiskey, and vodka should not be legally sold in the USA unless these products contain sufficient radioactivity; biofuels are radioactive, etc. Radiation is ubiquitous and needs to be understood properly by the public in friendly and familiar terms to help alleviate unfounded fear.

The public's fear of radiation is unnecessarily heightened because the terms and units that are used to measure the level of radiation are diverse and formidably complicated for the general public to understand [2,3]. The public and even many scientists and engineers are genuinely intimidated by the terms and units of radiation that seem to be monopolized by the experts. Efforts to explain radiation terms and units to the public are almost invariably met with blank stares, embarrassment, or even disdain, as ignorance can breed distrust. Radiation scientists and nuclear engineers have long since ignored the fact that their customers are not accustomed to the scientific terms and units of radiation. The absence of a common language between the public and the nuclear and radiation community has greatly hampered communication between these two groups, and as a result, public acceptance for nuclear power and radiation technology has been marginalized. The public's misunderstanding is amplified by the scientific jargon used by radiation experts and nuclear engineers when they communicate with the public. Many popular articles have been written that lament the public's ignorance about radiation and address the importance of and the need for public's correct understanding of radiation. Yet, there has not been a sincere attempt by the nuclear and radiation community to alleviate the public's fear by developing a common tool of communication that can facilitate the public's understanding. We attempt to improve this situation by introducing a new radiation scale in this study.

Communicating the matters related to radiation safety, nuclear accidents, and medical radiation in terms of scientific units such as Becquerel (Bq), Gray (Gy), Sievert (Sv), and their variations using micro and milli units has confounded and alienated the public, contributing enormously to elevating the public's anxieties about radiation due to mistrust rooted in discomfort with scientific verbiage.

Table 1 shows "SI derived units" defined by the Bureau International des Poids et Mesures (International Bureau of Weights and Measures) in the field of ionizing radiation. All radiation-related quantities or concepts in specific fields such as radiation science and radiation protection are based on these three SI derived units that are foreign to most people. To further complicate the situation, SI prefixes such as milli, micro, or kilo are used with any of these special names and symbols.

Table 2 lists various radiation dose concepts, all of which are basically a certain amount of energy imparted to a mass of target, but each describes a different concept, as defined in the table.

Additionally, previously other units, such as Roentgen, rem, rad, etc., were used to describe radiation doses [5,6].

To further complicate the matter, the kinetic energy of individual radiation particles is expressed by the units of eV, keV, or MeV, and the intensity of a radiation beam is often expressed by fluence (number of particles per unit area) or flux (number of particles per unit time to a given area) in radiation metrology.

These units are largely monopolized by radiation experts, and the public has extremely little interest in using them, let alone interest in learning the significance of all these units and conversions between them that are often necessary.

We propose a new radiation index that is friendly and simple for laymen to understand and use as a common tool of communication between them and the radiation community. In analogy with familiar units popularized in other areas, notably the seismic magnitude scale, acoustic intensity level, and hydrogen ion concentration in liquid (pH), all of which are dimensionless and simple, the new radiation unit proposed in this study should be friendly enough for the public to embrace it in their daily conversations when discussing radiation-related matters such as radiation safety, nuclear accidents, radiological medical diagnosis, radiation therapy, etc. The scale we propose will, therefore, be necessarily dimensionless and bear no scientific terminology. We will decide a reference point in the most proper manner and define any other level of radiation dose relative to this reference point as radiation index (*RAIN*), our new scale. That is, the new index will explicitly relate specific radiation levels to a commonly accepted reference radiation level via RAIN. In the following sections, the concept of RAIN will be developed, its relation to the scientific terms will be established, and applications in some practical areas will be exemplified.

2. Definition of the new concept, RAIN

We set some guiding principles in defining RAIN, which are as follows: (1) The new radiation index should be an international number, and easy to use in daily conversations and discussions among average people requiring little or no scientific knowledge of radiation and related subjects. (2) It should allow the general public to "feel" the meaning of the numbers expressed in the new scale in a similar manner to the popular seismic magnitude scale, acoustic intensity level (dB), and hydrogen ion concentration in liquid (acidity, pH);

Table 1 – SI derived units in the field of ionizing radiation [4].

Name	Symbol	Expressed in terms of other SI units	Expressed in terms of SI base units	Derived quantity
Becquerel	Bq		/sec	Activity referred to a radionuclide
Gray	Gy	J/kg	m^2/sec^2	Absorbed dose, specific energy (imparted), kerma
Sievert	Sv	J/kg	m^2/sec^2	Effective dose, ambient dose equivalent, directional dose equivalent, personal dose equivalent, etc.

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