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W&H aims Advanced Infection prevention Management Solutions

Logarithm, exponentiation and their connection to microorganisms

A well-established fact of natural science is that microorganisms grow at an exponential rate. Dependent on replication rates any given microorganism will double in numbers within a particular timeframe, this corresponds to repeated multiplication which is the mathematical definition of exponentiation i.e. $b^n = b \times b \ldots x\ b$ [1, 2]. Simultaneously thermal destruction of microorganisms, as seen in steam sterilisation, follows the inverse function of exponentiation, the logarithm. In the simplest case, the logarithm counts the number of occurrences of the same factor in repeated multiplications e.g. $100 = 10 \times 10 = 10^2$ or 2 log [1, 2].

Consequently, when lethal conditions are applied, microorganisms will be gradually killed off following a logarithmic function approximating zero (also see **thermal destruction**).

A reduction of 1 log cycle (- 1 log) equals a reduction of 90% of the present microbial population. Hence a reduction of 6 log cycles (- 6 log) equals the irreversible inactivation of 99.9999% of the original microbial population, which equates to a 1:1,000,000 probability and is considered sterile or germ-free [2].

Calculation example:	
Original population: 1 million bacteria 1,000,000 equals 10^6 equals 6 log	**Original population:** 100%
Reduction: 1 log cycle equals -1 log 6 log – 1 log = 5 log or $10^6 / 10^1 = 10^5$	-90% (-900,000 bacteria)
Rest population: 100,000 bacteria	**Total reduction:** 90% of original population

Calculation example:	
Remaining population: 100,000 bacteria 5 log – 1 log = 4 log or $10^5 / 10^1 = 10^4$ **Rest population:** 10,000 bacteria	**Remaining population** estimated as 100% -90% (-90,000 bacteria) **Total reduction:** 99% of original population
Remaining population: 10,000 bacteria 4 log – 1 log = 3 log or $10^4 / 10^1 = 10^3$ **Rest population:** 1,000 bacteria	**Remaining population** estimated as 100% -90% (-9,000 bacteria) **Total reduction:** 99.9% of original population
Remaining population: 1,000 bacteria 3 log – 1 log = 2 log or $10^3 / 10^1 = 10^2$ **Rest population:** 100 bacteria	**Remaining population** estimated as 100% -90% (-900 bacteria) **Total reduction:** 99.99% of original population
Remaining population: 100 bacteria 2 log – 1 log = 1 log or $10^2 / 10^1 = 10^1$ **Rest population:** 10 bacteria	**Remaining population** estimated as 100% -90% (-90 bacteria) **Total reduction:** 99.999% of original population
Remaining population: 10 bacteria 1 log – 1 log = not defined or $10^1 / 10^1 = 10^0$ **Rest population:** 1 bacterium	**Remaining population** estimated as 100% -90% (-9 bacteria) **Total reduction:** 99.9999% of original population

Note: Mathematically numbers can be written out in different manners e.g. 1000 or 10x10x10 or 10^3 or 3 log
Note: A reduction of 1 log cycle can also be expressed as 90% reduction

Bibliography:
[1] ÖSGV Fachkundelehrgang: Weiterbildung Sterilgutversorgung – Grundlagen der Aufbereitung von Medizinprodukten
[2] Encyclopedia of Mathematics