THE SO-CALLED "MAXIMUM ALLOWABLE BIOLOGICAL CONCENTRATIONS"

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The maximum allowable biological concentration of a toxic substance is the highest concentration which can be found in a biological medium without damage to health.

The biological materials may be examined for:

(a) the toxic substance itself;

(b) a product of the metabolism of the toxic substance in the body;

(c) a substance derived from the physiopathological activity of the toxic substance;

(d) radiations emitted by radioactive materials.

Table 1 illustrates these four possibilities.

Table 1. Examples of what is measured in assessing the maximum biological concentrations of industrial poisons

(a) Poisons	Pb	Cd	Mn	Ni
	Cr	As	F	C_6H_6
	CO	Some radioisotopes		
(b) Metabolites	Trichloracetic acid			
	Hippuric acid			
	Benzoic acid			
(c) Products of physio-pathological activity	Urinary organic sulphates			
	Serum cholinesterase			
	Carboxyhaemoglobin			
	Methaemoglobin			
(d) Radiations emitted by radioisotopes	α-ray radiations			

The biological medium which is examined for the substance in question is usually the urine or the blood; in particular cases the expired air, the faeces, and the hair may have to be studied. For some radioactive substances it is possible to calculate the maximum allowable concentration (M.A.C.) in the whole body, or in the critical organ. *Table 2* shows the biological medium usually employed for the analysis of some substances of toxicological interest.

Table 2. Maximum allowable biological concentrations in use at the Clinica del Lavoro, Milan

Poison	*Substance analysed*	*M.A.C. value*	*Biological medium*
Lead	Lead	0·150 mg/l.	Urine
Lead	Lead	0·8 mg/l.	Blood
Lead	Coproporphyrin	0·1 mg/l.	Urine
Lead	Protoporphyrin	1·0 mg/l.	Red (blood) cells
Tetraethyl lead	Lead	0·07 mg/l.	Blood
Mercury	Mercury	0·1 mg/l.	Urine
Chromium	Chromium	0·05 mg/l.	Urine
Arsenic	Arsenic	0·1 mg/l.	Urine
Arsenic	Arsenic	3 μg/g	Hair
Benzene	Organic sulphates	70% of total sulphates	Urine
Trichlorethylene	Trichloracetic acid	50 mg/l.	Urine
Acetone	Acetone	50 mg/l.	Blood
Acetone	Acetone	100 mg/l.	Urine
Acetone	Acetone	120 mg/l.	Expired air
Toluene	Hippuric acid	2·4 g/24h	Urine
Parathion	Cholinesterase activity	Decrease by 5% daily	Blood
CO	CO-Hb	14% of total Hb	Blood
CO	CO	3 cm^3%	Blood
CO	CO	0·014%	Expired air
Hydrofluoric acid	Fluoride ions	2 mg/l.	Urine

ADVANTAGES OF DETERMINING THE BIOLOGICAL CONCENTRATIONS

The M.A.C.'s in the atmosphere indicate how much of a given substance may be inhaled; therefore they are only valid for substances which enter the body *via* the respiratory organs. They are not valid for substances which enter the body through the skin.

Conversely, the maximum allowable biological concentrations indicate how much of a given substance has been adsorbed by the organism, irrespective of the mode of entry. Therefore, they are valid, also, for substances which enter the body through the skin, as for instance benzidine, tetraethyl lead, *etc.* In the dyestuff industry we have encountered workers showing measurable amounts of benzidine in their urine, although no benzidine was detectable in the atmosphere of their place of work.

The determination of the biological concentration is particularly useful in cases involving a short exposure to a high concentration of a toxic substance; in such cases it is often impossible to measure the concentration in the air at the moment of the accident. Acute exposures to trichlorethylene represent an example of such conditions.

In some jobs the atmospheric concentrations of an industrial poison may vary considerably from moment to moment and from place to place, according to the activity of the worker. Under these conditions it may be difficult to take measurements in the air, and it may be preferable to take an overall measurement of the adsorption by the body. Examples may be found in operations using mercury, benzene, *etc.*

Very often workers are sent to a clinic for suspected occupational poisoning when there is no opportunity of ascertaining the concentration of the poison in the atmosphere of the place of work.

Finally, the measurement of a substance which is the result of the physiopathological effect of an industrial poison may provide information on the reaction of the organism to that poison, and, therefore, be preferable to the determination of the poison itself either in the air or in the biological fluids. This is true, for instance, with the urinary coproporphyrin in workers exposed to lead, and with cholinesterase activity of the blood in people exposed to parathion.

LIMITATIONS OF THE MAXIMUM ALLOWABLE BIOLOGICAL CONCENTRATIONS

There are many limitations to determining maximum allowable biological concentrations. The most important are:

(a) for most of the irritant poisons it is impossible to have maximum allowable biological concentrations: for instance for chlorine, hydrogen chloride, sulphur dioxide, sulphur trioxide, nitrogen dioxide, phosgene, phosphorus oxychloride, *etc.*;

(b) some metals, like lead, are normally found in the body and body fluids. The so-called " normal " concentrations of these metals vary according to environment and diet. These " normal " concentrations may influence the rate of excretion of some poisons;

(c) some biological concentrations may be influenced by variations in ability of different individuals to eliminate the poison. This may be due to a detectable disease of the kidney or liver, or to some other, maybe unknown, cause. Furthermore, there may be individual differences in the metabolism of a toxic substance in the body, so that the amount of a metabolite in the urine may not be consistent with the amount of the toxic substance absorbed.

The urinary content of some toxic substances may vary considerably in the course of a day and from day to day. In these cases it is advisable to examine a sample of the 24-hours urine, and perhaps to repeat the examination for some days. Finally, some analyses present technical difficulties; it is therefore necessary to standardize the technique used in order to have significant results. This is the case in the analysis of expired air.

The advantages and disadvantages of determining biological concentrations, as opposed to concentrations in the air, make the meaning and importance of the former somewhat different from those of the latter. Both represent, in their own way, a very useful means of preventing occupational diseases, and of improving industrial hygiene and safety.

Quantitative analysis of toxic substances in biological materials are currently performed in every institute of industrial medicine. But there is not yet much agreement on either the maximum allowable biological concentrations, or on the importance of some analyses. It is my firm belief that the preparation of an internationally accepted list of maximum allowable biological concentrations will be of great help to all interested in industrial toxicology and hygiene. In some cases, this list will have paramount importance. I am referring to some carcinogenic substances which are easily absorbed through the skin, *e.g.*, benzidine, and to radioisotopes.

Investigations have been started on the correlation between maximum allowable quantities of a radioisotope in the body and in the expired air. Knowledge of these correlations may be of great importance in preventing damage due to ionizing radiations.