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WATER QUALITY REQUIREMENTS FOR DIFFERENT USES

by

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I "STREAM STANDARDS" FOR THE RECIPIENTS' WATER QUALITY

"Stream standards" for the water quality of recipients often contain water quality classes which may be imposed

- (a) regardless of the utilization of the water of watercourses;
- (b) having regard to the utilization of waters in different fields of the production branches (industry, agriculture, etc.)

In case of (a) water quality is considered only, whereas in that of (b) it is attempted to take into account the requirements of users.

Two of the standards concerned with the water quality of recipients are mentioned here.<sup>(1)</sup> One is the CMEA (COMECON) draft standard. The most important limit values thereof are presented in the Table 1. In the COMECON standard the utilization of watercourses is implicitly taken into consideration by definitions of the I, II, III, IV categories. The possibilities of water uses prescribed for the individual categories are shown in Table 2.

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The other classification method applied widely in Hungary takes primarily into account the waters' usability in the various fields of production branches (industry, agriculture, etc.).<sup>(2)</sup> The constituents relevant for the individual branches can be seen in Table 3.

## II WATER QUALITY REQUIREMENTS OF THE INDIVIDUAL WATER USES

The water quality requirements of the individual water management branches will be discussed as follows:

1. Drinking water supply
2. Industrial water supply
3. Agricultural water supply (irrigation, animal husbandry)
4. Fishery
5. Recreation
6. Hydro-power and navigation.

The classical (physical and chemical) parameters of the water quality will be dealt with in this exposition. To survey the limit values concerning the refractory organics (micropollutants), as well as the biological, bacteriological and radioactive components, respectively, would far exceed the objectives of the present paper.

The effect upon water quality resulting from 1 400 most common chemical, biological, bacteriological and radioactive components and the allowable limit values thereof are dealt with in a paper<sup>(3)</sup> consisting of 1 000 pages based on 3 800 items of references.

### 1. Drinking Water Supply

Drinking water (generally in community water supply) is the most important use of waters. The water used for this purpose should meet the highest requirements. This fact, however, does not mean that the limit values are strictest for drinking water, because for particular purposes of industrial water supply the limit values applied should be more severe than those for drinking water.

When determining standards for drinking water supply the quality of waters should be tested at two points:

- (a) at the source of water supply system (raw water), and
- (b) on the site of use. at water taps (treated water: drinking water).

(In the case of subsurface waters diverted to the pipe network without treatment these two points coincide with each other). As a consequence of the growing pollution of surface waters, the water quality at these two points differs more and more. To overcome this problem is the task of water treatment technology. However, water quality standards concerning both points mentioned above are needed for designing technology and operating water works. The standards for drinking water (tap water) and those of raw waters as the raw material of the former are discussed separately.

#### 1.1 Drinking Water Standards

There is a great variety in the drinking water standards valid in different countries of the world. WHO is attempting to coordinate those set forth in the International Drinking Water Standards<sup>(4)</sup> in 1958 and subsequently in the European Drinking Water Standards<sup>(5)</sup> in 1961. The former recommends minimum requirements which can presumably be met under present conditions all over the world, whereas the latter takes into account that due to the technical and economic position of Europe being above the average world level, higher requirements can also be satisfied there. When elaborating these, the drinking water standards of USA having a considerable past in this regard, were considered. These standards set forth in 1914, 1925, 1942, 1946 show clearly the advance made.<sup>(6)</sup>

The above standards limit the water quality on the basis of bacteriological, physical, chemical and radioactive components as regards maximum allowed and recommended limit values.

## 1.2 Raw Water Standards for Drinking Water Supply

The basic principle of raw water standards for drinking water supply is very simple, namely having been treated conventionally (sedimentation, flocculation, filtration, chlorination) it should meet the above drinking water standards.

Numerous experiments have been performed to realize this principle in practice, i.e. to produce raw water standards.

The relevant experiences in the USA are summed up in Table 4.<sup>(3)</sup> In this compilation raw water (including subsurface waters) is classified into I, II and III classes respectively, according to whether the conversion thereof into drinking water needs only disinfection, conventional treatment or a special treatment occasionally.

Table 5 contains a similar compilation but for surface waters only on the basis of West-German data.<sup>(7)</sup> In group A, drinking water can be obtained at a reasonable cost; the treatment of waters in group B can be performed uneconomically only, while in the case of group C the treatment for drinking water is out of question.

The various raw water standards are compatible as shown by Table 6, wherein the following three prescriptions are compared with each other

- (a) Column 2 of Table 4 based on experiences in USA,
- (b) Column A of Table 5 based on West-German data,
- (c) Class 1 in CMEA (COMECON) draft standard (water for community water supply).

## 2. Industrial Water Supply

Water is one of the most important auxiliaries in industrial production. It may play several roles: as one part of the product similarly to other raw materials, or used either for delivering and cleaning, or as coolant and steam, or in producing energy.

Quality of water used for industrial purposes may vary considerably depending on the type of plant. This is why it is impossible to elaborate unified standards for waters used in the various industrial processes. The water may have more functions within the plant, and the water quality requirements thereof may differ from each other considerably. A typical case is where a factory needs different qualities for the purposes of boiler feed-water, cooling water and process water.

Industry tends to require drinking water quality for its production processes. This may lead to wastage where a poorer water quality would also be sufficient. Where a higher quality is required than that of drinking water (e.g. feed-water to boiler of high pressure), the industrial plants usually acknowledge their own responsibility for further water treatment.

Stability is a basic requirement of water quality in every branch of industry. Once production is embarked upon or switched over to a certain water quality suitable for a certain technology, any change in water quality involves significant economic losses for the plant (8.9).

Different adverse effects of inadequate or changing water quality are liable to appear in industrial production. These can be grouped as follows: <sup>(3)</sup>

Adverse effects in final products

- (a) chemical reactions
- (b) biological reactions
- (c) corrosion
- (d) discolouration, taint

Damages in manufacturing equipment

- (a) corrosion
- (b) cavitation
- (c) scale formation

Capacity decrease

- (a) deposits in equipment
- (b) slurry formation in equipment
- (c) foam formation in equipment.

The synthesis of water quality requirements of industries can amply be found in literature on the subject (8, 9, 10, 11, 12, 13, 14). These are, however, rather contradictory since water quality requirements depend on the current technology. An abstract of the relevant East-German prescriptions is presented in Table 7.

Details of the water quality requirements in the different industrial branches would exceed the objectives of this paper, therefore only the references available are enumerated below according to the various branches of industry.

- (a) aluminium industry<sup>(15)</sup>
- (b) concrete fabrication<sup>(16,17)</sup>
- (c) tanneries<sup>(18,19)</sup>
- (d) pulp and paper industry<sup>(18)</sup>
- (e) sugar refinery<sup>(19)</sup>
- (f) fermentation<sup>(20, 21, 22, 23)</sup>
- (g) photography<sup>(18)</sup>
- (h) electro plating<sup>(14, 18)</sup>
- (i) cooling water<sup>(18, 24, 25)</sup>
- (j) ice production<sup>(26)</sup>
- (k) boiler feed-water<sup>(8, 14, 27)</sup>
- (l) chemical industries<sup>(9, 11, 19)</sup>
- (m) cannery<sup>(22, 28)</sup>
- (n) plastic industry<sup>(19)</sup>
- (o) synthetic fibre manufacturing<sup>(19, 29)</sup>
- (p) brewery<sup>(18, 20, 21, 3)</sup>
- (q) bakery<sup>(18, 31)</sup>

- (r) dairy (22)
- (s) textile industry (18, 32)
- (t) soft drinks industry (30, 33)
- (u) iron- and steel industry (18, 34, 35)

### 3. Agricultural Water Supply

#### 3.1 Irrigation

The literature on the subject presents a detailed review of water quality components affecting adversely the use of water for irrigation as well as the more or less harmful concentrations thereof. <sup>(3)</sup> Owing to different soil and agrotechnical conditions a certain prescription cannot be applied in all countries. Hungarian standards divide waters into three groups depending on the total dissolved salts, percentage of sodium and phenolphthalein alkalinity in terms of sodium carbonate: <sup>(36)</sup>

- A. Waters usable for every soil
- B. Waters usable for particular soils
- C. Waters usable **exceptionally**.

Table 8 can be referred to for details. It is to be noted that marks a, b and c in the table mean waters of hydrocarbonate, hydrocarbonate-sulphate and hydrocarbonate chloride type respectively.

#### 3.2 Animal Husbandry

The generally adopted view is that water suitable for human purposes is suitable for animals. Nevertheless this requirement cannot always be met, and it is not necessary always to observe it.

Investigations have shown that the salt tolerance of the most important species of animals which play a role in animal husbandry is higher than that of man. The safe upper limits for salt content are presented in Table 9, adapted from Australian

data. (37) According to US investigations (3) based on total salt content, waters are classified into four classes from the point of view of animal husbandry (Table 10).

Regardless of total salt concentration, particular salts are specifically poisonous for animals even in low concentration. Some harmful substances in waters are nitrates, chlorides and the salts of selenium and molibden. These can cause physiological disturbances in egg and dairy productions.

Data in Table 11 represent the classical water quality components. It should be noted that threshold concentration means the limit value at which the livestock is liable to suffer a slight damage. The lower concentration is practically ineffective.

#### 4. Fishery

Fish stock not only obtains food from water but that is the medium of its existence. Thus, the abundance of literature dealing with the effect of pollution on aquatic life is understandable. Unfortunately, the comparable interpretation of numerous studies is very difficult, because the investigations generally were conducted under different conditions, with different methodologies applied (3, 37). Besides in principle it is very difficult to impose unified standards owing to the changing effect of harmful pollutants on fish:

- (a) according to the size, age and physiological conditions of species,
- (b) according to the physical and chemical composition of waters,
- (c) depending on the hydrological conditions (low water, high water).

In Table 12 the limit values of some physical and chemical components are presented for which the limit values of literature - connected with the fresh-water fisheries - are in fairly good agreement. (3, 37, 38)



It should be said that the data serve for information only and that satisfactory results can only be obtained occasionally by biological experiments. The methodology of these experiments is standardized in the developed countries. (39)

## 5. Recreation

Water usable for recreation (swimming, water sports) should meet the following three requirements: (40, 41)

- (a) it should give a good impression,
- (b) it must not contain harmful pollutants for human health internally or externally,
- (c) it must not contain more pathogenic bacteria than allowed.

Prescriptions concerning (a) and (b) are of qualitative, describing character. Only the requirement (c) connected with the pathogenic bacteria has numerical limit values.

## 6. Hydro-power and Shipping

The following pollutants are undesirable from the aspect of hydro-power and shipping: (3)

- (a) strong acids, alkalies, salt solutions of high concentration causing corruptions and cavitation,
- (b) substances which result in gas formation may cause corrosion finally,
- (c) algae, fungi which may cause clogging in pipelines or cling to ships,
- (d) floating oil film which may give rise to risk of fire.

It is understandable that numerical limit values have not been given for the above pollutants in the literature because by the time the water becomes dangerous for ship and turbines it had been previously unsuitable for other purposes of water supply.

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TABLE I

CLASSIFICATION OF WATERCOURSES ACCORDING TO THEIR QUALITY

(Abstract from "Water Pollution Control",

Budapest, 1966, WHO Copenhagen)

The following table comprises the classification concept of surface waters in the (CMEA) countries.

It may be noted that the substances governing this classification have been dealt with in the WHO International Standards for Drinking Water Report.

COUNCIL FOR MUTUAL ECONOMIC AID (CMEA)

APPROVED BY THE HEADS OF THE WATER MANAGEMENT AUTHORITIES OF  
MEMBER STATES OF THE CMEA AT THEIR SECOND SESSION, 22 JUNE 1963

		Class			
	Unit	I	II	III	
A1	Dissolved oxygen	(O <sub>2</sub> ) mg/l	> 6	> 5	> 3
			The results of night and morning samples not to be taken into account		
A2	Dissolved oxygen % of saturation	(O <sub>2</sub> ) %	> 75	> 50	> 30
			The results of night and morning samples not to be taken into account		
A3	BOD <sub>5</sub>	(O <sub>2</sub> ) mg/l	> 5	> 10	> 15
A4	Oxidability per- manganate value KMnO <sub>4</sub>	(O <sub>2</sub> ) mg/l	< 10	< 15	< 25
			Excluding waters containing humic substances		
A5	Free hydrogen sulfide	H <sub>2</sub> S mg/l	N.D.*	N.D.*	0.1
A6	Biological condi- tion, saprobity	oligo-beta beta-meso alpha-meso	-		alpha-meso
B1	Chloride ions	Cl <sup>-</sup> mg/l	< 200	< 300	< 400
B2	Sulfate ions	SO <sub>4</sub> <sup>2-</sup> mg/l	< 150	< 250	< 300

\* N.D. signifies the presence of a quantity too small to be demonstrated

TABLE 1 (cont'd)

		Unit	Class		
			I	II	III
B3	General hardness	German degrees	< 20	< 30	< 40
B4	Calcium ions	Ca <sup>2+</sup> mg/l	< 150	< 200	< 300
B5	Magnesium ions	Mg <sup>2+</sup> mg/l	< 50	< 100	< 200
B6	Dry residue of matter in solution	mg/l	< 500	< 800	< 1 200
B7	Suspended matter in flow in dry weather	mg/l	< 20	< 30	< 50
C'1	Ammonium ions	NH <sub>4</sub> <sup>+</sup> mg/l	< 1	< 3	< 10
C'2	Nitrate ions	NO <sub>3</sub> <sup>-</sup> mg/l	< 13	< 30	-
C'3	pH	-	6.5-8.5	6.0-8.5	5.5-9.0
			excluding naturally acid waters		
C'4	Total iron	Fe mg/l	< 0.5	< 1	< 1.5
			excluding waters containing humic substances		
C'5	Manganese	Mn mg/l	< 0.1	< 0.3	< 0.8
C'6	Volatile phenols with water vapour	mg/l	< 0.002 <sup>+</sup>	< 0.02	-
C'7	Detergents (active washing substances)	mg/l	< 1	< 2	< 3
			Only for anionic washing substances. For other substances special maximum limits must be established where appropriate methods of analysis are available.		
C'8	Cyanide ions	CN <sup>-</sup> mg/l	< 0.01	< 0.02	< 0.1
			Take into account compound cyanides as necessary. Each country should establish its own depending on climatic conditions.		
C'9	Temperature	- °C	establish its own depending on climatic conditions.		
C'10	Smell and taste	-	Not noticeable	Not out of the ordinary	At the most only slightly out of the ordinary

TABLE 1 (cont'd)

	Unit	Class		
		I	II	III
C'11 Colouring	-	At the present time indication of exact data is impossible on account of analytical difficulties. Can be included in the classification depending on given circumstances.		
C'12 Oils	-	Invisible	Traces only	Traces only
C'13 Coli titre	-	0.1	0.01	-
		In determining the general coli content in accordance with the lowest titre values		
C'14 Pathogenic microbes	-	N.D.*	N.D.*	N.D.*

\* N.D. signifies the presence of a quantity too small to be demonstrated.

TABLE 2  
CATEGORIES RELATING TO TYPES OF UTILIZATION  
IN THE CMEA DRAFT STANDARD

Category	Type of Use	Characterization
I	(a) community water supply (b) food industry and other industries with similar requirements (c) trout fishery (d) bathing with high requirements	Clean water
II	(a) fishery excluded trout fishery (b) sport and recreation (c) animal husbandry	Slightly polluted
III	(a) agricultural irrigation (b) industry	Polluted water
IV	usable after expensive treatment only	Slightly polluted



TABLE 3

COMPONENTS TO BE TAKEN INTO CONSIDERATION IN COMMUNITY,  
INDUSTRIAL AND AGRICULTURAL WATER SUPPLY

(Abstract from the Instruction of Hungarian National Water  
Authority No. 62.931/1966)

<u>Branch</u>	<u>Component</u>
Community water supply	Oxygen consumption
	Oxygen saturation
	pH
	Cyanide
	Ether extract
	Phenols
	Detergents (anionactive)
Industrial Water Supply	pH
	Total hardness
	Total dissolved matter
	Total suspended solids
	Ether extract
Irrigation	pH
	Total dissolved matter
	Sodium percentage
Agriculture, Fishery	Oxygen saturation
	Ammonium
	Sulphide
	Ether extract
	Phenols
	Biological conditions

TABLE 4

RAW WATER LIMIT VALUES ON THE BASIS OF US EXPERIENCES

Component	Dimension	I	II	III
		Raw water of excellent (very good) quality (needs disinfection only)	Raw water of good quality (needs the treatment customary)	Raw water of bad quality (needs a specific treatment)
BOD <sub>5</sub> (average)	mg/l	0.75 to 1.5	1.5 to 2.5	> 2.5
BOD <sub>5</sub> (max.)	mg/l	1.0 to 3.0	3.0 to 4.0	> 4.0
Dissolved oxygen (average)	mg/l	4.0 to 7.5	4.0 to 6.5	4.0
Oxygen saturation (average)	%	> 75	75 to 60	-
pH (average)	-	6.0 to 8.5	5.0 to 9.0	3.8 to 10.5
Chloride	mg/l	< 50	50 to 250	> 250
Fluoride	mg/l	< 1.5	1.5 to 3.0	> 3.0
Phenol	mg/l	-	0.005	> 0.005

TABLE 5

RAW WATER LIMIT VALUES FOR SURFACE WATER ON THE BASIS OF WEST GERMAN EXPERIENCES

Component	Dimension	A Water suitable for water treat- ment at real cost	B Water suitable for water treat- ment at great cost	C Water unsuitable for water treat- ment
Oxygen saturation	%	> 60	60 to 30	< 30
pH	-	6 to 9	5 to 6 or 9 to 10	< 5, > 10
Chloride-ion	mg/l	< 150	150 to 350	> 350
Phenol	mg/l	< 0.005	0.1	> 0.1
Total hardness	German degree	< 20	20 to 30	> 30
Iron	mg/l	< 0.5	0.5 to 1.5	> 1.5
Manganese	mg/l	< 0.25	0.25 to 0.5	> 0.5
Ammonium-ion	mg/l	< 0.2	0.2 to 0.1	> 1
Nitrite-ion	mg/l	traces only	< 2	> 2

TABLE 6

COMPARISON OF VARIOUS DRINKING RAW WATER STANDARDS

Component	Dimension	Raw water of good quality (needs customary treatment) USA	Water suitable for water treat- ment at real cost GFR	Water suitable for community water supply CMEA
BOD <sub>5</sub>	mg/l	< 3.0 - 4.0	-	< 5.0
Dissolved oxygen	mg/l	4.0 - 6.5	-	> 6.0
Oxygen saturation	%	60 - 75	> 60	> 75
pH	-	5.0 - 9.0	6.0 - 9.0	6.5 - 8.5
Chloride-ion	mg/l	50 - 250	< 150	< 200
Phenol	mg/l	0.005	< 0.005	< 0.002
Total hardness	German degree	-	< 20	< 20
Iron	mg/l	-	< 0.5	< 0.5
Manganese	mg/l	-	< 0.25	< 0.1
Ammonium-ion	mg/l	-	< 0.2	1.0

TABLE 7

WATER QUALITY LIMIT VALUES FOR SEVERAL INDUSTRY BRANCHES  
RELATING TO THIRTEEN WATER QUALITY COMPONENTS BASED ON DATA OF GDR

Component	Dimension	Industry branch				
		Tannery	Pulp paper ind.	Concrete fabric- ation	Sugar Refinery	Food Ind.
Dissolved oxygen	mg/l	4	4	4	-	5
BOD <sub>5</sub>	mg/l	12	12	12	-	6
Oxygen consumption (KMnO <sub>4</sub> )	mg/l	15	15	15	-	10
Chloride-ion	mg/l	250	-	250	250	100
Sulphate-ion	mg/l	250	-	250	250	100
Total hardness	German degree	8	8	16	16	8
Total suspended solids	mg/l	20	10	20	-	10
Temperature	°C	-	-	26	-	-
Iron	mg/l	0.6	0.2	0.2	-	0.2
Manganese	mg/l	0.6	0.2	0.6	-	0.2
Heavy metals	mg/l	0.15	0.1	0.15	-	0.05
Cyanide	mg/l	0.1	0.1	0.1	-	0.0
Phenols	mg/l	1.0	0.2	0.2	-	0.02

TABLE 7 (cont'd)

Component	Dimension	Industry branch				
		Cooling waters	Boiler feed water	Loundry works	Chemical industry	textile industry
Dissolved oxygen	mg/l	-	-	6	5	5
BOD <sub>5</sub>	mg/l	-	12	3	6	6
Oxygen consumption (KMnO <sub>4</sub> )	mg/l	-	15	5	10	10
Chloride-ion	mg/l	250	-	100	250	-
Sulphate-ion	mg/l	250	-	100	250	-
Total hardness	German degree	16	8	4	4	8
Total suspended solids	mg/l	20	20	5	10	10
Temperature	°C	22	26	-	-	-
Iron	mg/l	0.6	-	0.2	0.2	0.2
Manganese	mg/l	0.6	-	0.2	0.2	0.2
Heavy metals	mg/l	0.15	0.15	0.05	0.05	0.1
Cyanide	mg/l	0.1	0.1	0.1	0.1	0.1
Phenols	mg/l	0.2	0.2	0.2	0.2	0.2

TABLE 8

WATER CLASSIFICATION FROM THE ASPECT OF APPLICABILITY FOR IRRIGATION

Applicability	Type of soil	Type of water	Total dissolved salt	Sodium percentage	Phenol-ftalein alkali-nity
		mg/l	mg/l	mg/l	mg/l =
A) Applicable to every soil	-	a	< 500	< 35	< 10
	-	b	< 500	< 40	< 10
	-	c	< 500	< 45	< 10
B) Applicable to non-sodaic soils	To loam soils	a	500-650	< 35	< 10
		b	500-650	< 40	< 10
		c	500-650	< 45	< 10
	to sandy-loam soils	a	650-800	< 35	< 10
		b	650-800	< 40	< 10
		c	650-800	< 45	< 10
	to sandy soils	a	800-1 000	< 35	< 10
		b	800-1 000	< 40	< 10
		c	800-1 000	< 45	< 10
C) Applicable exceptionally (to sodaic soils)	to sodaic pasture lands	a	< 800	30-65	10-50
		b	< 800	40-75	10-50
		c	< 800	40-75	10-50
	to sodaic pasture lands with sandy subsoils	a	> 1 000	> 35	> 50
		b	> 1 000	> 40	> 50
		c	> 1 000	> 45	> 50

TABLE 9

THE UPPER LIMIT OF SALT CONTENT BASED ON AUSTRALIAN DATA

<u>Animal Species</u>	<u>Threshold salt concentration</u>
poultry	2 900
pig	4 300
horse	6 400
dairy cattle	7 200
meat cattle	10 000
lamb	12 900

TABLE 10

CLASSIFICATION OF WATERS USED FOR ANIMAL HUSBANDRY  
ON THE BASIS OF TOTAL DISSOLVED SALT ACCORDING TO US INVESTIGATIONS

<u>Category</u>	<u>Total dissolved salt (mg/l)</u>
I very good	1 000
II good	1 000 - 4 000
III satisfactory	4 000 - 7 000
IV unsatisfactory	7 000



TABLE 11  
GUIDING NUMBERS TO CONSIDERATION OF WATER QUALITY  
FROM THE ASPECT OF LIVESTOCK

Component	Dimension	Threshold concentration	Limit concentration
Calcium-ion	mg/l	500	1 000
Magnesium-ion	mg/l	250	500
Sodium-ion	mg/l	1 000	2 000
Chloride-ion	mg/l	1 500	3 000
Nitrite-ion	mg/l	200	400
Sulphate-ion	mg/l	500	1 000
pH	-	6.0 - 8.5	5.6 - 9.0

TABLE 12  
LIMIT VALUES FOR WATER QUALITY RELATING TO FISHERY

Constituents	Dimension	Threshold concentration
Total dissolved matter	mg/l	2 000
pH	-	6.5 - 8.5
Dissolved oxygen min.	mg/l	5.0
Free CO <sub>2</sub>	mg/l	1.0
Chromium (VI)	mg/l	0.05
Copper	mg/l	0.02
Cyanide	mg/l	0.02
Mercury	mg/l	0.01
Nickel	mg/l	0.05
Lead	mg/l	0.1