INTRODUCTION TO AQUATIC SCIENCES

5. Week	Water quality for aquaculture

Introduction to Aquatic Sciences

WEEKLY TOPICS (CONTENT)

Week	Topics
1. Week	Aquaculture in Turkey and world
2. Week	The role of fish in human consumption
3. Week	What is fish? Taxonomy of fish
4. Week	Aquatic Crustacean
5. Week	Water quality for aquaculture
6. Week	Introduction to marine fish
7. Week	Introduction to freshwater fish
8. Week	Live foods (microalgae, zooplankton and *Artemia*)
9. Week	Introduction to fishing techniques
10. Week	Fish transport
11. Week	Introduction to fish disease
12. Week	Introduction to fisheries economy
13. Week	Processing and marketing of fish
14. Week	Introduction to fisheries and aquaculture management

Water Quality; is an indicator for physical, chemical and biological properties of water.
Water quality standard is determined according to aim of usage of water (drinking, agriculture, industry, energy etc.) and water classes (river, lake, coastal and transitional waters and ground water)
Beside these, to achieve good water status in all aforesaid waters in an integrated approach, more general water quality standards can be determined. These quality standards are divided into two as receiving bodies standards and discharge standards.
Discharge standards are determined to control discharges resulting from sectoral activities in quality aspects.
Receiving body standards are allowable concentrations of the substances in the receiving bodies and it is used effectively to protect the quality of water resources.
Discharge standards maintain controlling of pollution factors into water resources, and receiving body standards keep control of current quality of water.

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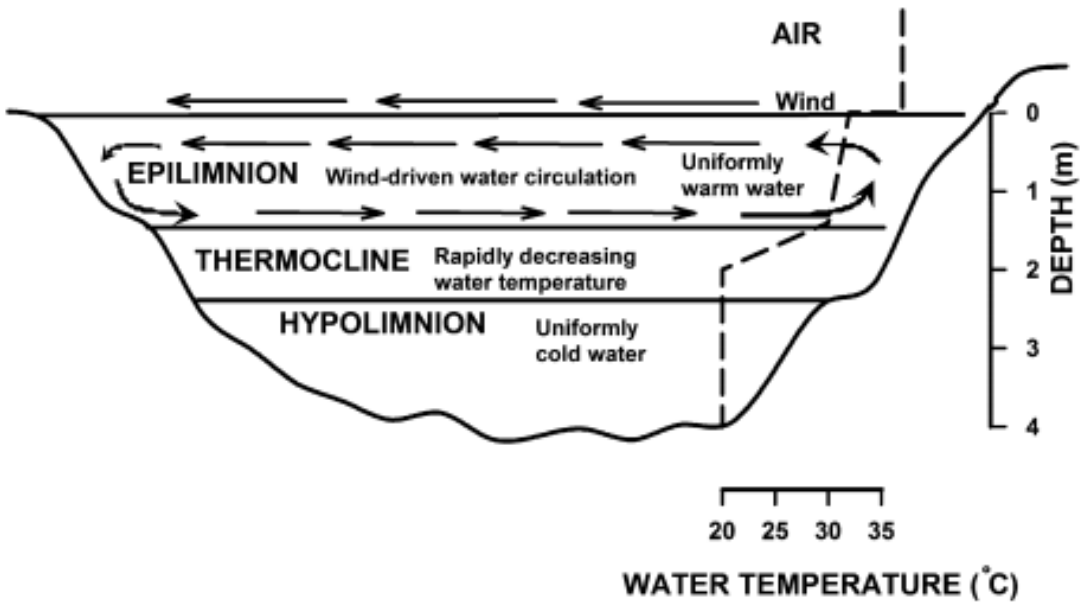

Fig. 1.12 Thermal stratification in a small lake

Table 2.1 Volumes of ocean water and different compartments of freshwater

Compartment	Volume (km^3)	Proportion of total (%)	Renewal time
Oceans	1,348,000,000	97.40	37,000 years
Freshwater			
Polar ice, icebergs, and glaciers	27,818,000	2.01	16,000 years
Groundwater (800–4,000 m depth)	4,447,000	0.32	–
Groundwater (to 800 m depth)	3,551,000	0.26	300 years
Lakes	126,000	0.009	1–100 years
Soil moisture	61,100	0.004	280 days
Atmosphere (water vapor)	14,400	0.001	9 days
Rivers	1,070	0.00008	12–20 days
Plants, animals, humans	1,070	0.00008	–
Hydrated minerals	360	0.00002	–
Total freshwater	(36,020,000)	(2.60)	–

Renewal times are provided for selected compartments (Baumgartner and Reichel 1975; Wetzel 2001)

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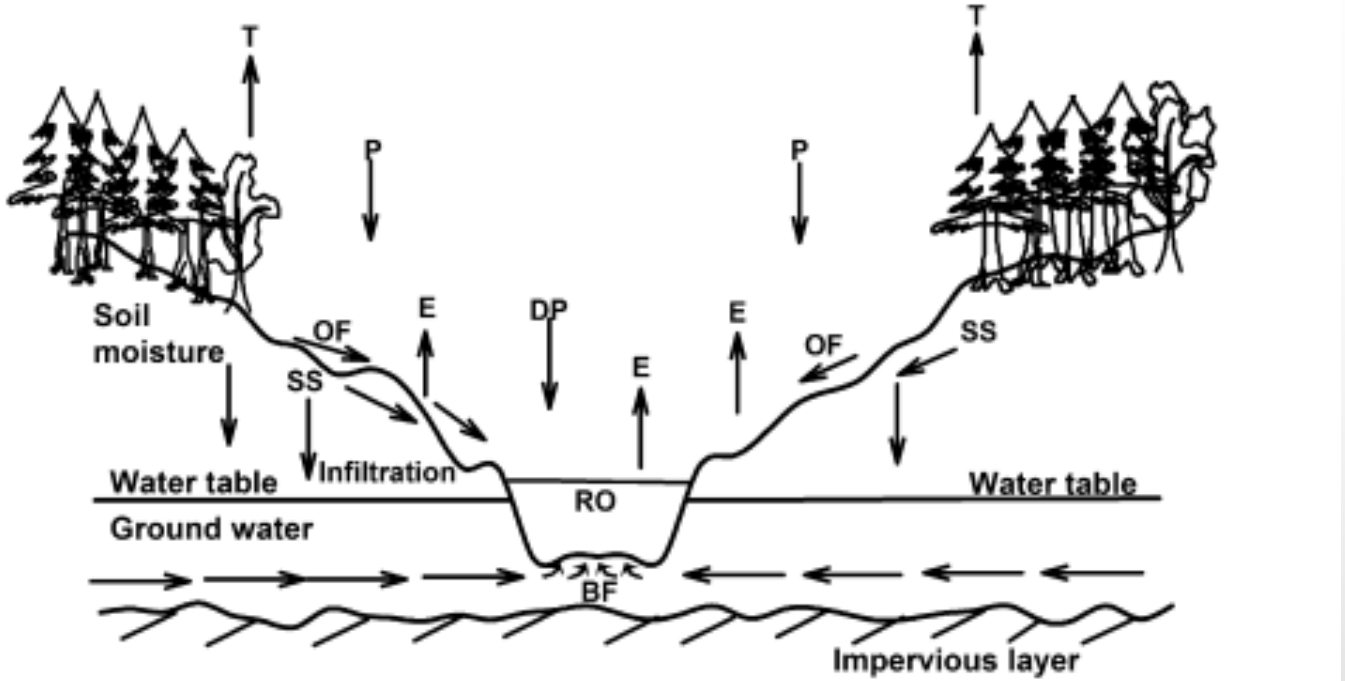

Fig. 2.1 The hydrologic cycle or water cycle

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Table 6.5 Effects of dissolved oxygen concentration on warmwater fish

Dissolved oxygen (mg/L)	Effects
0–0.3	Small fish survive short exposure
0.3–1.5	Lethal if exposure is prolonged for several hours
1.5–5.0	Fish survive, but growth will be slow and fish will be more susceptible to disease
5.0–saturation	Desirable range
Above saturation	Possible gas bubble trauma if exposure prolonged

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Microorganisms and Water Quality

Phytoplankton and bacteria have a greater effect on water quality than do other aquatic microorganisms. Phytoplankton are the main primary producers while bacteria are responsible for the majority of organic matter decomposition and nutrient recycling. An overview of microbial growth, photosynthesis, and respiration is provided, and methods for measuring primary production and respiration in water bodies are discussed. The combined physiological activities of producer and decomposer organisms in water bodies cause pH and dissolved oxygen concentration to increase and carbon dioxide concentration to decrease in daytime, while the opposite occurs during nighttime. In unstratified water

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Micronutrients and Other Trace Elements

The solubilities of most minerals from which trace metals in natural waters originate are favored by low pH. The concentration of the free ion of a dissolved trace element usually is much lower than is the total concentration of the trace element. This results from ion pair associations between the free trace ion and major ions, complex ion formation, hydrolysis of metal ions, and chelation of metal ions. Several trace elements—zinc, copper, iron, manganese, boron, fluorine, iodine, selenium, cadmium, cobalt, and molybdenum—are essential to plants, animals or both. A few other trace elements are suspected but not unequivocally proven to be essential. There are some reports of low micronutri-

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Water Quality Regulations

Water quality regulations are important for avoiding conflicts among water users, minimizing public health risks of certain chemical and biological pollutants, protecting the environment, and preventing conditions that lessen the recreational and aesthetic value of water bodies. Most countries have devel-

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Table 1.1 Solubility of oxygen in water exposed to water-saturated air* (mg/litre).

	Salinity (‰)				
Temperature (°C)	0	8.75	17.5	26.25	35
0	14.6	13.8	13.0	12.1	11.3
5	12.8	12.1	11.4	10.7	10.0
10	11.3	10.7	10.1	9.6	9.0
15	10.2	9.7	9.1	8.6	8.1
20	9.2	8.7	8.3	7.9	7.4
25	8.4	8.0	7.6	7.2	6.7
30	7.6	7.3	6.9	6.5	6.1
35	7.1	—	—	—	—
40	6.6	—	—	—	—

*Values are quoted for 760 mmHg pressure. Under any other barometric pressure, P, the solubility S' (mg/litre) is given by

$$S' = S\frac{P-p}{760-p}$$

Table 1.2 Interrelationships between pH value and the hydrogen and hydroxyl ion concentrations in a dilute aqueous solution.

	Acid solutions								Neutral		Alkaline solutions				
Hydrogen ion (H^+) concentration (g/litre)	1	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}	10^{-7}	10^{-8}	10^{-9}	10^{-10}	10^{-11}	10^{-12}	10^{-13}	10^{-14}
Equivalent pH value	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Hydroxyl ion (OH^-) concentration (g/litre)	10^{-14}	10^{-13}	10^{-12}	10^{-11}	10^{-10}	10^{-9}	10^{-8}	10^{-7}	10^{-6}	10^{-5}	10^{-4}	10^{-3}	10^{-2}	10^{-1}	1
Equivalent pOH value	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Roberts, R. J. (2012). *Fish pathology*. John Wiley & Sons.

Table 1.3 Effects of temperature on selected dissociation constants.

	Temperature (°C)						
	0	5	10	15	20	25	30
pK_A of water	14.939	14.731	14.533	14.345	14.167	13.997	13.832
pK_A of sea water	14.947	14.739	14.541	14.353	14.175	14.005	13.840
First dissociation constant of carbonic acid (K_A)	2.64*	3.04*	3.44*	3.81*	4.16*	4.45*	4.71*
pK_A of first dissociation constant of carbonic acid	6.58	6.52	6.46	6.42	6.38	6.35	6.33
Dissociation constant of ammonia (K_B)	1.374†	1.479†	1.570†	1.652†	1.710†	1.774†	1.820†
pK_B of ammonia	4.862	4.830	4.804	4.782	4.767	4.751	4.740

*$\times 10^{-7}$; † $\times 10^{-5}$.

Table 1.4 Variation in percentage of molar concentration of carbonic acid, bicarbonate and carbonate at different pH values and at two temperatures in fresh water.

	8°C			24°C		
pH	H_2CO_3	HCO_3^-	CO_3^{2-}	H_2CO_3	HCO_3^-	CO_3^{2-}
5.0	96.9	3.1	0	95.9	4.1	0
5.5	91.0	9.0	0	88.2	11.8	0
6.0	75.8	24.2	0	70.0	30.0	0
6.5	49.7	50.3	0	42.4	57.6	0
7.0	23.6	76.4	0	18.9	81.1	0
7.5	8.8	91.2	0	6.9	92.9	0.2
8.0	3.0	96.7	0.3	2.3	97.3	0.4
8.5	1.0	98.1	0.9	0.6	97.9	0.9
9.0	0.3	96.7	3.0	0.3	95.3	4.4
9.5	0.1	90.9	9.0	0	87.2	12.8
10.0	0	76.9	23.1	0	68.5	31.5

Roberts, R. J. (2012). *Fish pathology*. John Wiley & Sons.

Table 1.6 Variation in percentage of undissociated ammonia in aqueous ammonia solution with temperature and pH.

Temperature (°C)	pH value							
	6	6.5	7	7.5	8	8.5	9	9.5
0	0.008	0.026	0.083	0.261	0.820	2.55	20.7	45.3
5	0.013	0.040	0.125	0.400	1.23	3.80	28.3	55.6
10	0.019	0.059	0.186	0.590	1.83	5.56	37.1	65.1
15	0.027	0.087	0.273	0.860	2.67	7.97	46.4	73.3
20	0.0400	0.125	0.400	1.24	3.82	11.2	55.7	79.9
25	0.057	0.180	0.570	1.77	5.38	15.3	64.3	85.1
30	0.081	0.254	0.800	2.48	7.46	20.3	71.8	89.0

After Emerson *et al.* (1975). For sea-water values, see Whitefield (1974).

Table 1.7 Classification of saline waters.

Name		Salinity (‰)
Hyperhaline	sea water	>40
Euryhaline		30–40
Polyhaline		18–30
Mesohaline a	brackish water	10–18
Mesohaline b		1.84–10
Oligohaline		0.21–1.84
Fresh water		<0.21

Table 1.8 The constituents in solution in an ocean water of salinity 35‰.

Constituent	Content*
Sodium	11.1
Magnesium	1.33
Calcium	0.42
Potassium	0.39
Strontium	0.01
Chloride	19.8
Sulphate (as SO^{2-})	2.76
Bromide	0.066
Boric acid (as H_3BO_3)	0.026
Bicarbonate, carbonate, molecular CO_2	
pH 8.4	0.023
pH 8.2	0.025
pH 8.0	0.026
pH 7.8	0.027
Dissolved organic matter	0.001–0.0025
Oxygen (saturated value)	0.0074
Other elements	0.005

*g/litre at 20°C (SG 1.025).

Roberts, R. J. (2012). *Fish pathology*. John Wiley & Sons.

Table 1.9 Selected environmental parameters important for fish health and their recommended safe levels.

Parameter		Fresh water		Sea water
Total dissolved gas pressure (%)		110		110
Total dissolved nitrogen pressure (%)		110		110
pH			6.5 to 8.5 = 0.5 units	
Suspended solids (µg/litre)				
	High level of protection	<25	The nature of the solid material may greatly influence safe level	
	Moderate level of protection	25–80		
	Low level of protection	80–400		
Carbon dioxide (high level of protection) (µg/litre)		<6		—
Cadmium (µg/litre)		0.03 at >100 mg/litre hardness 0.04 at <100 mg/litre hardness		0.2
Chromium (mg/litre)		0.05		0.05
Copper		0.1 × LC_{50} of water		0.01 × LC_{50} of water
Lead (mg/litre)		0.03		0.01
Mercury (mg/litre)		0.05		Unknown
Nickel		0.02 × LC_{50} of water		0.02 mg/litre
Zinc		0.05 × LC_{50} of water		
Undissociated ammonia (mg/litre)		0.02		0.01
Cyanide (mg/litre)		0.005		0.005
Undissociated hydrogen sulphide (mg/litre)		0.002		0.005
Pesticides, PCBs		See *Water Quality Criteria* (US Environmental Protection Agency 1972).		

CHARACTERISTICS OF DIFFERENT TYPES OF WATER

SURFACE WATERS

Rivers and streams

Lake waters

GROUND AND SPRING WATERS

SEA WATER

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References

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