Water Quality Management

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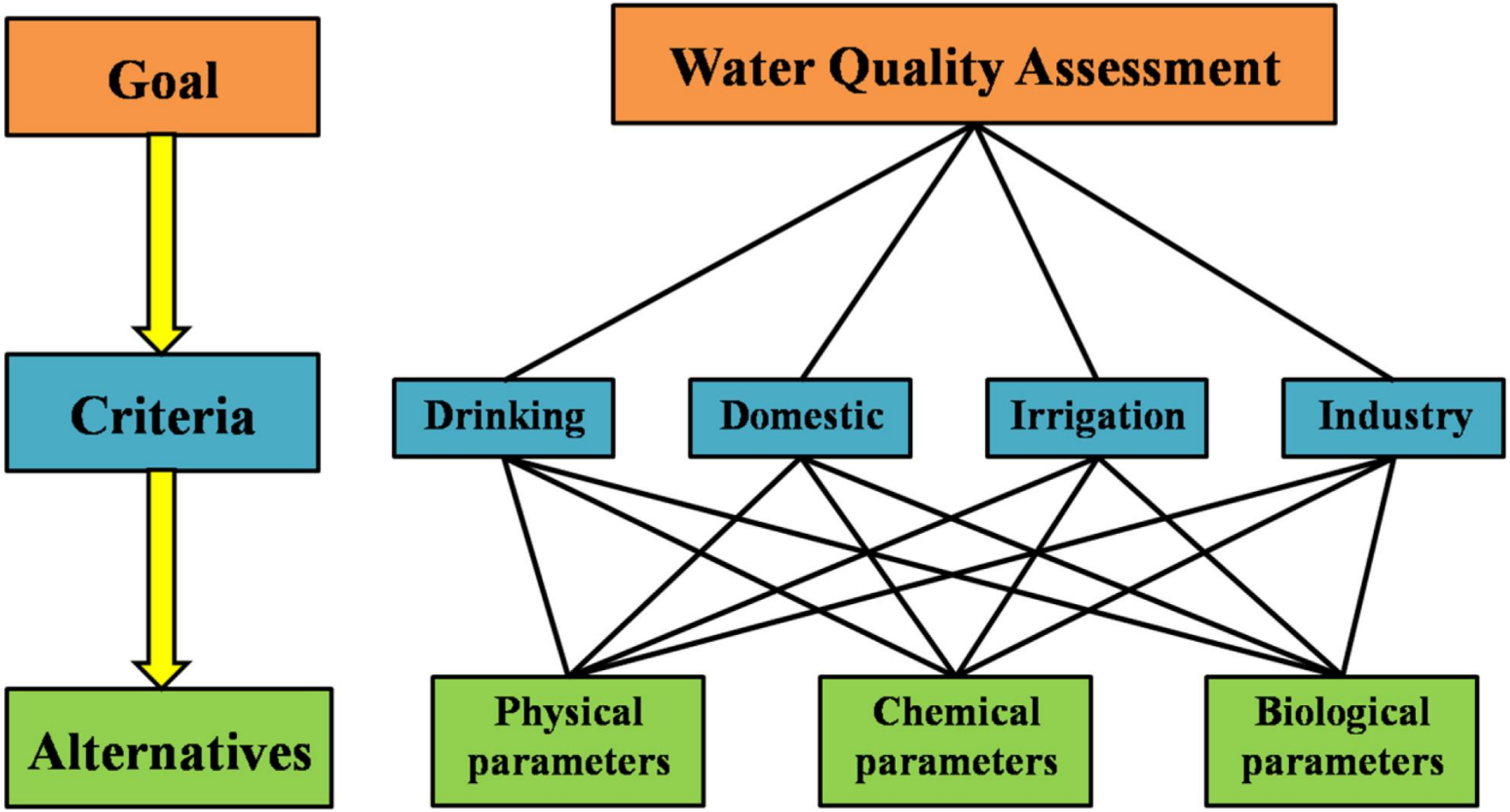
Topic I – Lecture 2 and 3

سرفصل

- **هدف از توسعه منابع آبی یا استفاده های سودمند (Beneficial use) آب**
- **آب شرب**
- **آبیاری کشاورزی**
- **آب صنعتی**
- **اکوسیستم آبی**
- **تولید برق**
- **تفریحات**
- **دام و احشام**
- **شیلات**
- **آب بهداشتی**
- **کشتیرانی**
- **تغذیه آبخوان**
- **بازیافت پساب** (کشاورزی , تغذیه آبخوان , صنعتی و بهداشتی)
- **دیگر موارد** (ساختمانی , شستشوی ماشین .....)

- **مفهوم معیار**
- **تعریف استاندارد**
- **مبانی تنظیم استاندارد**


Goal
Criteria
Alternatives
Water Quality Assessment
Drinking
Domestic
Irrigation
Industry
Physical parameters
Chemical parameters
Biological parameters

Water quality criteria are the scientifically defensible characteristics necessary for the protection of aquatic life and human health. After considering political, economic, and technological feasibility, water managers may set standards, which are legally enforceable for the protection of human health and aquatic life. Table 1 is a summary of definitions related to the development of water quality criteria and setting of water quality standards.

Table 1. Criteria and standards for water quality and some definitions

Water quality criteria	Best scientific data (measures) for protection of aquatic life (marine and freshwater) and human health
Water quality standards	Legally enforceable standards for protection of aquatic life and human health; may consider political, economic, and technological feasibility as well as site-specific conditions; states may make standards more stringent than federal government, but not less stringent
Beneficial use designations	1. Recreational class waters (primary contact, secondary contact such as boating, and children's recreation such as wading) 2. Aquatic life class waters (coldwater fisheries, warmwater fisheries, sensitive species waters, including rivers, lakes, wetlands, or reservoirs) 3. Drinking water classification for potable water supplies
Biological criteria	Best scientific measures designed to protect ecological integrity (numerical and/or narrative criteria may be employed)
Maximum contaminant level	A drinking water quality standard designed to protect human health

Table 1. Water quality criteria for diverse uses

Class	Designated best use (DBU)	Criteria
A	Drinking water source without conventional treatment but after disinfection	pH: 6.5–8.5 Dissolved oxygen: 6 mg l^{-1} or more Biological oxygen demand: 2 mg l^{-1} or less Total coliform: 50 MPN per 100 ml
B	Outdoor bathing (organized)	pH: 6.5–8.5 Dissolved oxygen: 4 mg l^{-1} or more Biological oxygen demand: 3 mg l^{-1} or less Total coliform: 500 MPN per 100 ml
C	Drinking water source with conventional treatment followed by disinfection	pH: 6.5–8.5 Dissolved oxygen: 4 mg l^{-1} or more Biological oxygen demand: 3 mg l^{-1} or less Total coliform: 5000 MPN per 100 ml
D	Propagation of wildlife and fisheries	pH: 6.5–8.5 Dissolved oxygen: 4 mg l^{-1} or more Free ammonia: 12 mg l^{-1}
E	Irrigation, industrial cooling, and controlled waste disposal	pH: 6.5–8.5 Electrical conductivity: 2250 Sodium adsorption ratio: 26 Boron: 2 mg l^{-1}

Abbreviation: MPN, most probable number.

Table 1 - Surface Water Criteria by Classification

Parameter	Class AA	Class A	Class B	Class SA	Class SB
Aesthetics	Uniformly excellent.	Uniformly excellent.	Good to excellent.	Uniformly excellent.	Good to excellent.
Dissolved Oxygen	Not less than 5 mg/l at any time.	Not less than 5 mg/l at any time.	Not less than 5 mg/l at any time.	Acute: Not less than 3.0 mg/l. Chronic: Not less than 4.8 mg/l with cumulative periods of dissolved oxygen in the 3.0 – 4.8 mg/l range as detailed in Note 1 to this table.	Acute: Not less than 3.0 mg/l. Chronic: Not less than 4.8 mg/l with cumulative periods of dissolved oxygen in the 3.0 – 4.8 mg/l range as detailed in Note 1 to this table.

Table 2. Priority pollutants

			Freshwater		Saltwater	
	Priority pollutant	CAS number	CMC 1 (acute) (µg l^{-1})	CCC 1 (chronic) (µg l^{-1})	CMC 1 (acute) (µg l^{-1})	C (c (µ
1	Antimony	7440360				
2	Arsenic	7440382	340[a,d,k]	150[a,d,k]	69[a,d,bb]	3(
3	Beryllium	7440417				
4	Cadmium	7440439	2.0[d,e,k,bb]	0.25[d,e,k,bb]	40[d,bb]	8.
5a	Chromium (III)	16065831	570[d,e,k]	74[d,e,k]		
5b	Chromium (VI)	18540299	16[d,k]	11[d,k]	1100[d,bb]	5(
6	Copper	7440508	Freshwater criteria calculated using the Biotic Ligand Model[mm] – see document (http://epa.gov/waterscience/criteria/copper/)		4.8[d,cc,ff]	3.
7	Lead	7439921	65[d,e,bb,gg]	2.5[d,e,bb,gg]	210[d,bb]	8.
8a	Mercury	7439976	1.4[d,k,hh]	0.77[d,k,hh]	1.8[d,ee,hh]	0.

Parameters	Maximum WHO permissible limit
Al	0.2 mg/L
Ca	75 mg/L
Fe	0.3 mg/L
Mg	50 mg/L
NO_3	50 mg/L
pH	6.5 - 8
TDS	1000 mg/L
E. coli	0

Table 2. Water quality criteria for metals in freshwater from the USA, Canada, Australia, the European Union (EU), Switzerland, and the Netherlands.

Country, criteria	References	B (μg l^{-1})	Al (μg l^{-1})	V (μg l^{-1})	Cr (μg l^{-1})	Mn (μg l^{-1})	Fe (μg l^{-1})	Co (μg l^{-1})	Ni (μg l^{-1})	Cu (μg l^{-1})
USA, EPA Acute	EPA, 2005		750		Cr(III) 570a				470[a]	Calculate with BL
					Cr(VI) 16					
USA, EPA Chronic	EPA, 2005		87		Cr(III) 74a		1000		52[a]	Calculate with BL
					Cr(VI) 11					
Canada Short-term	CCME, 1999a	29 000								
Canada Long-term	CCME, 1999a	1 500	5		Cr(III) 8.9		300		96[a]	2.4[a]
			100[b]		Cr(VI) 1					
Australia 95% Protection	PIMC, 2000	370	55[b]		Cr (VI) 1	1900			11	1.4
EU Annual average	EU, 2008								20	
Switzerland Dissolved	GSchV, 1998				2				5	2
Netherlands Target value	Warmer and Van Dokkum, 2002			0.9	0.3			0.2	3.3	0.5

Table 2: Suggested water quality standards[1]

	Dutch Standards		Canadian Standards	EPA Standards (Human)
Item	**No Risk**	**Risk**	**Maximum**	**Maximum**
pH	5-8	< 4 & > 9	.	6.5 - 8.5
Ammonia, ppm	< 1	> 2	.	.
Nitrite (as N), ppm	< 0.1	> 1	10	1
Nitrate (as N), ppm	< 25	> 100	100	10
Chloride, ppm	< 250	> 1,000	.	250
Salt (via Na), ppm	< 1,000	> 2,000	.	.
Iron, ppm	< 0.2	.	.	0.3
Manganese, ppm	< 1	> 2	.	0.05
Sulfate, ppm	< 100	> 250	1,000	500
Calcium, ppm	.	.	1,000	.
Total dissolved solids	.	.	3,000	500

[1]See Fact Sheet ANS 00-811S "Guidelines for Water Quality in Pigs" at https://projects.ncsu.edu/project/swine_extension/publications/factsheets/811s.htm for detailed information and references.

Source: North Carolina State University

Table 2.1: Drinking water quality: Chemical Parameters

Parameter	Standard Values For Asian Countries												
	Pakistan	India	Sri lanka	Nepal	China	Japan	Korea	Malaysia	Indonesia	Singapore	Philippine	Vietnam	WHO
Chemical Parameters													
As	≤500	Max. 0.01	0.01	Max. 0.05	0.01	0.01	0.05	0.01	0.05	0.05	Max. 0.05	0.05	0.01
Cd	0.01	Max. 0.003	0.003	Max. 0.003	0.005	0.01	0.005	0.003	0.1	0.01	Max. 0.003	0.01	0.003

Water variants	Acceptable levels for fish culture	Levels in wate where fish kills have occurred
Oxygen	>6ppm, up to 100%	<3ppm, >100% sat.
Carbon dioxide	1.5 - 3.0 ppm	>15ppm
PH	6.7 - 8.6	<4-5, >9-10
Ammonia (unionised)	<0.02 ppm	>0.2- 1.0 ppm
Nitrate	<1.0 ppm	>100 ppm
Nitrite	<0.1 ppm	>2.0 ppm (fresh)
		>20 ppm (salt)
Total hardness	20 - 200 ppm	>200 ppm (CO_2 excess)
Salinity		>800 ppm (all causes)
Total suspended solids	<80 ppm	>5000-100,000 ppm
Total dissolved solids	<400 ppm	>5000-20,00 ppm
Hydrogen disulphide	<0.002 ppm	>0.5-10 ppm
Heavy metals		
Aluminium	–	>0.1-5 ppm (low pH)
Cadmium	<0.005 ppm soft water	>3 ppm
	<0.003 ppm hard water	
Copper	<0.006 ppm	>0.5 ppm
Mercury	<0.0002 ppm	>0.15 ppm
Lead	<0.02 ppm	>1-5 ppm
Zinc	<0.005 ppm	>0.5-1.0 ppm

Table 9: Guidelines for Interpretation of water quality for Irrigation (FAO, 1985)

Potential irrigation problems	Units	None	Degree of restriction slight-moderate	Severe
Salinity				
EC_w[1]	dS m^{-1}	<0.7	0.7-3.0	>3.0
TDS	mg L^{-1}	<450	450-2000	>2000
Infiltration				
SAR2 = 0-3 and EC_w	>0.7		0.7-0.2	>.2
3-6	>1.2		1.2-0.3	>0.3
6-2	>1.9		1.9-0.5	>0.5
12-20	>2.9		2.9^{-1}.3	>1.3
20-40	>5.0		5.0-2.9	>2.9
Specific ion toxicity				
Sodium (Na)	SAR	<3	3-9	>9
Chloride (Cl)	me L^{-1}	<4	4-10	>10
Boron (B)	mg L^{-1}	<0.7	0.7-3.0	>3.0
Miscellaneous effects				
Nitrogen (NO_3-N)[3]	mg L^{-1}	<5	5-30	>30
Bocarbonate (HCO_3)	me L^{-1}	<1.5	1.5-8.5	>8.5
pH		Normal range = 6.5-8.4		

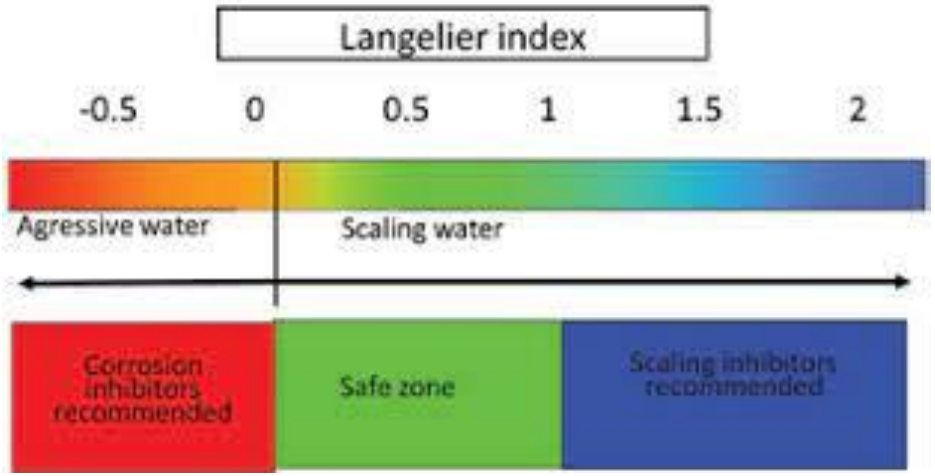
1: EC_W means Electrical conductivity of irrigation water at 25°C. 2: SAR means sodium adsorption ratio. 3: NO_3-N means nitrate nitrogen reported in terms of elemental nitrogen

Threshold Levels of Trace Elements for Crop production	
Element	Recommended maximum concentration (mg L^{-1})
Cadmium (Cd)	0.01
Copper (Cu)	0.20
Fluoride (F)	1.00
Iron (Fe)	5.00
Manganese (Mn)	0.20
Lead (Pb)	5.00

Table 9: Continue

Threshold Levels of Trace Elements for Crop production	
Element	Recommended maximum concentration (mg L^{-1})
Zinc (Zn)	2.00
Selenium (Se)	0.02
Arsenic (As)	0.10
Cobalt (Co)	0.05
Chromium (Cr)	0.10
Molybdenum (Mo)	0.01
Nickel (Ni)	0.20
Aluminum (Al)	5.00
Beryllium (Be)	0.10

The Langelier Index is an approximate measure of **the saturation degree of calcium carbonate (CaCO3) in water**. It is calculated using the Hydrogen Ion (pH) , Alkalinity (CaCO3), Calcium concentration, Total Dissolved Solids, and water temperature of a tap water sample



آب صنعتی

LSI Formula
A =(LOG_{10} * (TDS)-1) / 10
B = (-13.12 * LOG_{10}(temp +273)) + 34.55
C = LOG (CaH) – 0.4
D = LOG_{10}(M-Alk)
pHs = (9.3 + A + B) – (C + D)
LSI = pHa – pHs

Where;

TDS = Total Dissolved Solids(ppm)

temp = Temperature(dEG C)

CaH = Calcium Hardness(ppm as CaCO3)

M-Alk = M-Alkalinity(ppm as CaCO3)

pHs = Saturation pH

pHa = Actual pH

مثال

LSI Calculation Example:

pH	8.0
Total Dissolved Solids	500 mg/L
Temperature	30 dEG C
Calcium Hardness	250 ppm as $CaCO_3$
M-Alkalinity	100 ppm as $CaCO_3$

Lets Calculate..

Put cooling water analysis values in above LSI Formula. You get below values for constants A,B,C & D as per below table:

A	0.17
B	2.02
C	2.0
D	2.0
pHs	7.49

Finally, LSI = pHa – PHs

LSI = 8.0 – 7.49 = 0.51

The tendency of this water is slightly scale forming.

نیروگاه برق آبی

Visible gas bubbles in connective tissues of operculum and eye typical of acute gas bubble disease.

Left: Gas bubbles (arrow) trapped in capillaries of a gill lamella typical of gas bubble disease; **Right:** Gas bubbles in and around connective tissue of the mouth.

Gas supersaturation occurs **when the total dissolved gases in a body of water exceed the concentration of total gases that can be dissolved under normal circumstances** given the temperature, dissolved solids, and gas pressure above the water (usually determined by altitude).

One of the best-known causes of gas supersaturation is **entrainment of air bubbles when water falls over spillways of high dams**.

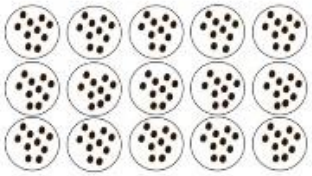
Types of Saturation	Definitions
Saturated Solution	A saturated solution is a solution that is in equilibrium with respect to a given dissolved substance.
Unsaturated Solution	A solution not in equilibrium with respect to a given dissolved substance and in which more substance can be dissolved.

Assessing water quality through:

- Ecotoxicological indicators

Rhinella arenarum

Toxicity bioassays



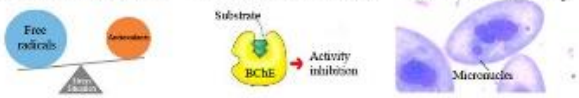
AS S1 S2 S3 S4

Embryos

Larvae

Biomarkers

• Oxidative stress • Neurotoxicity • Genotoxicity



Integrated Biomarkers Index (IBR)

- Physicochemical indicators

In situ In laboratory

+ metals
+ pesticides

Water Quality Index (WQI)

A degraded water quality was observed

IBR + WQI = significantly correlated

Figure 1. Transmission routes of COVID-19 virus to natural water bodies. WWTP = Wastewater treatment plant.

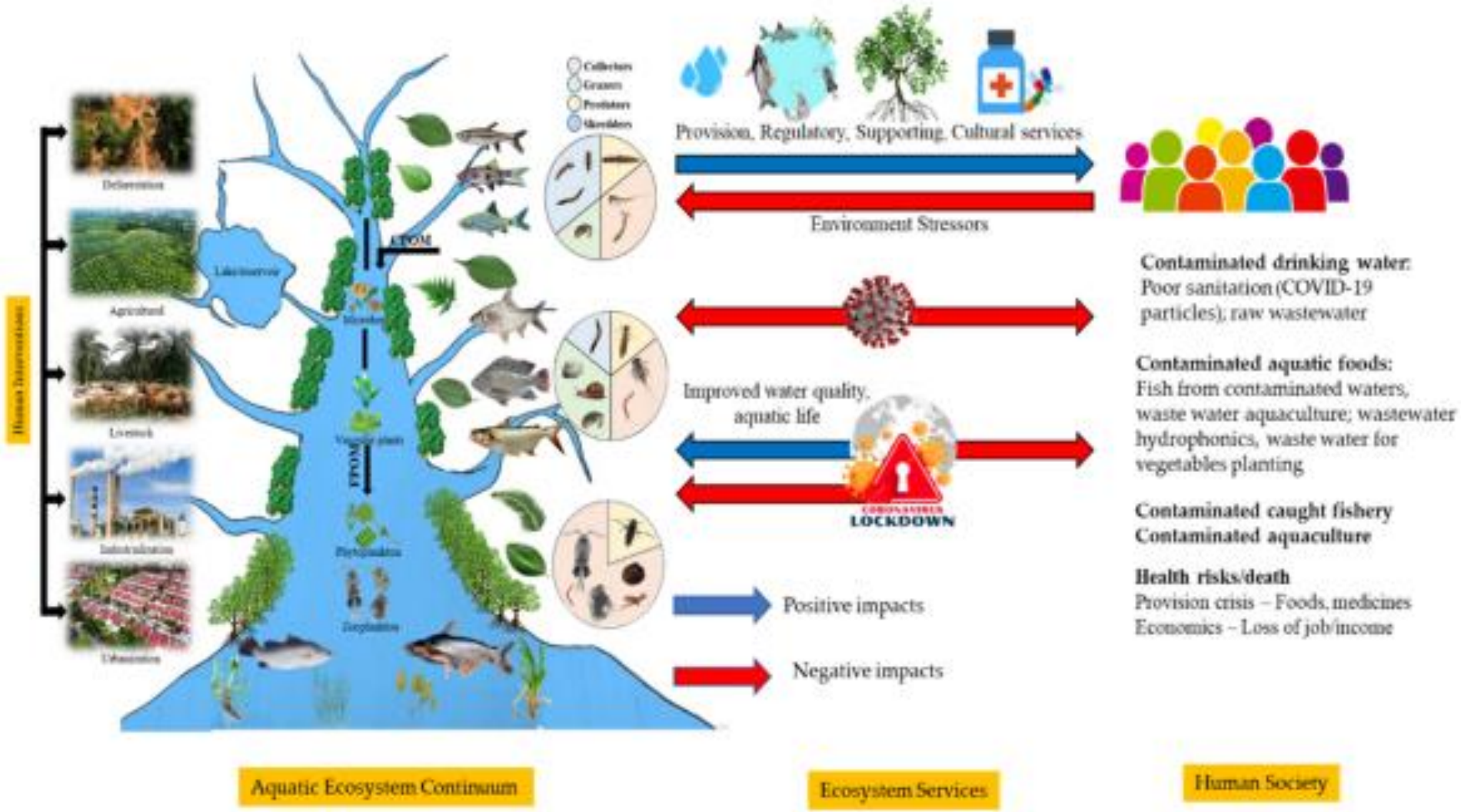
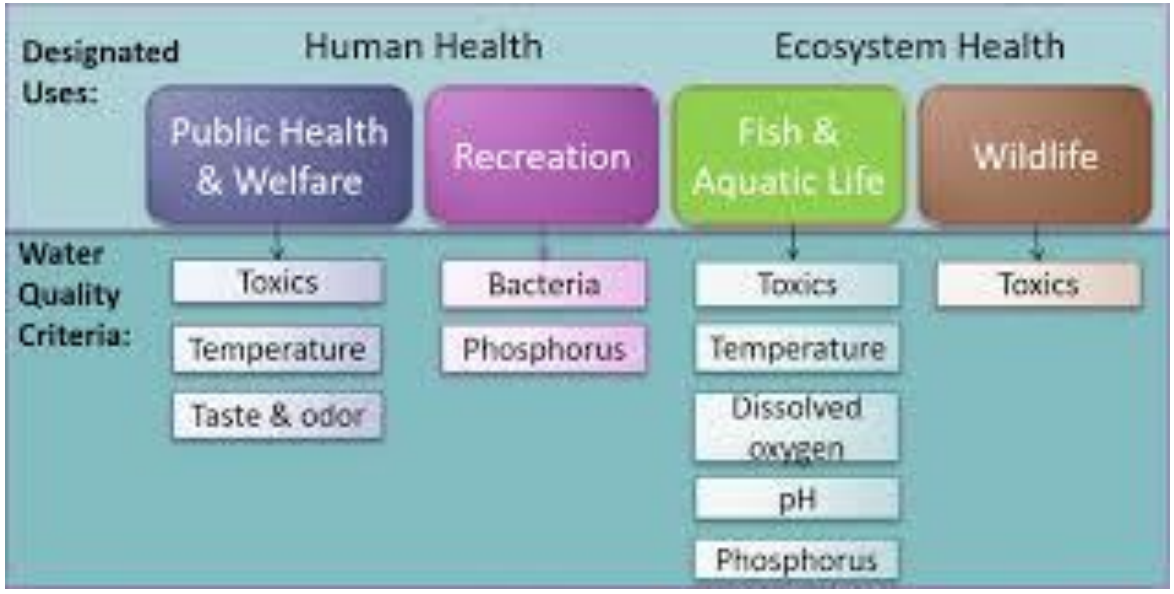
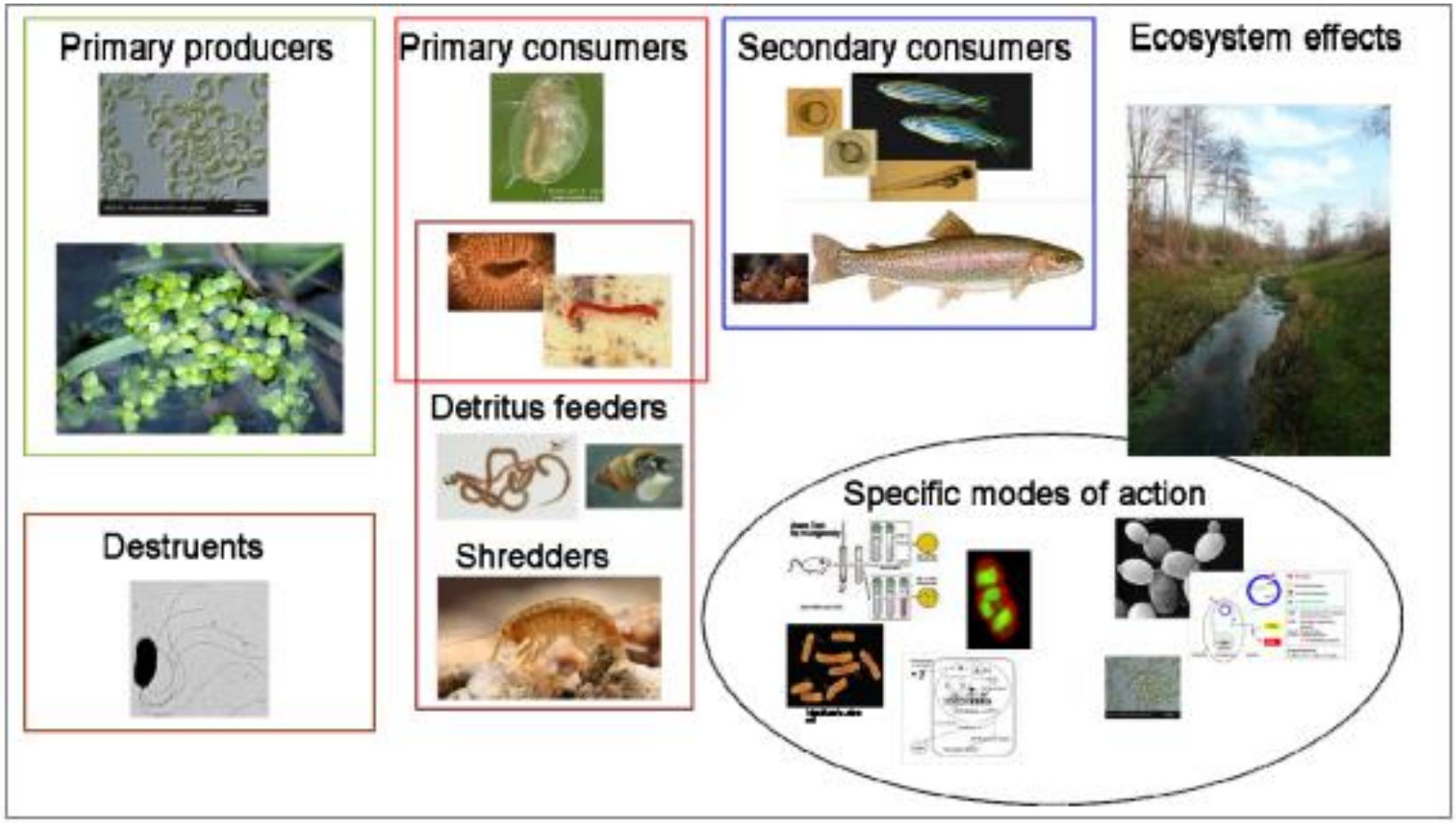
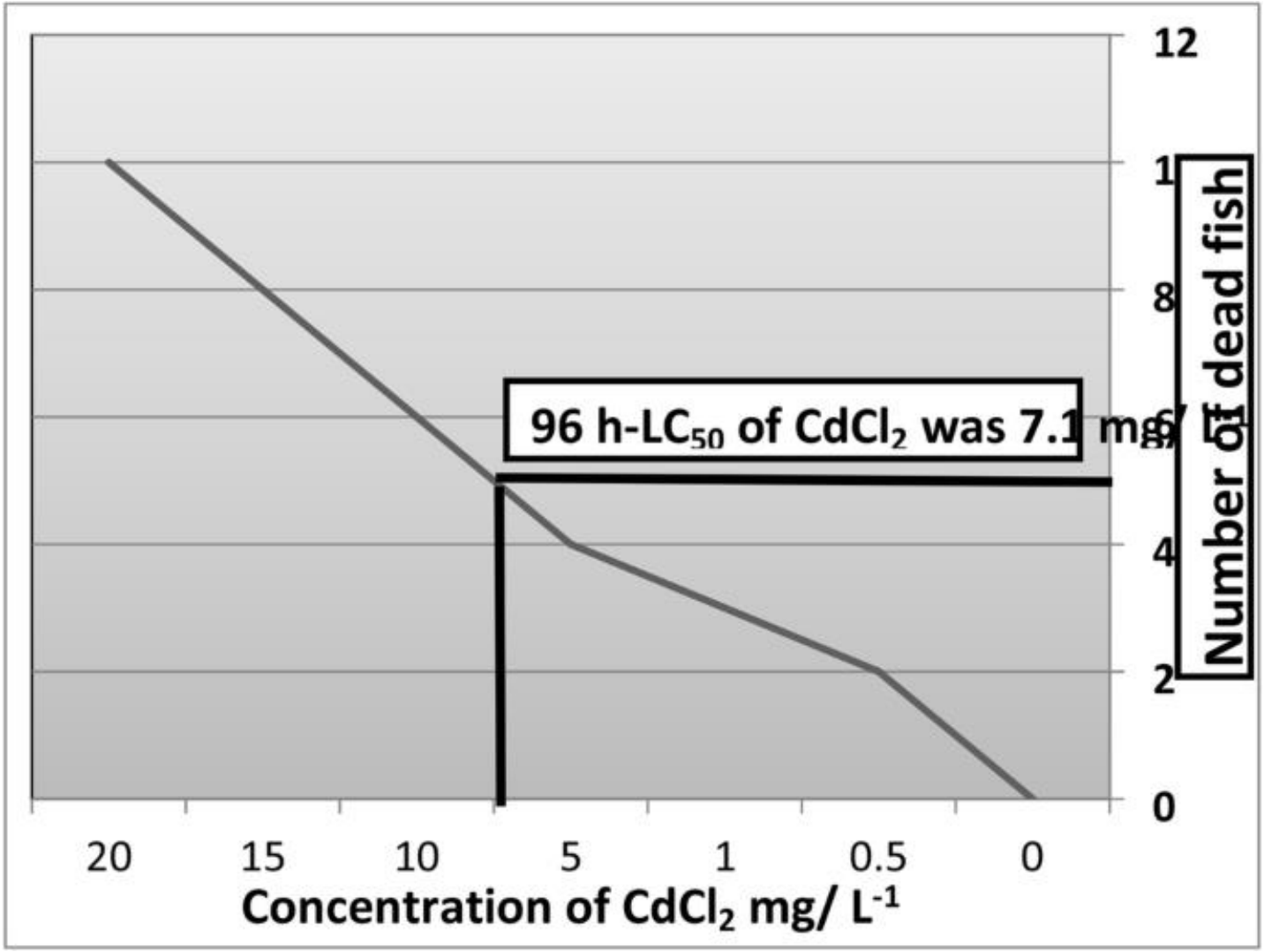


Figure 2. Impacts of COVID-19 on aquatic ecosystem-aquatic resources and human nexus.


Designated Uses:
Human Health
Ecosystem Health
Public Health & Welfare
Recreation
Fish & Aquatic Life
Wildlife
Water Quality Criteria:
Toxics
Temperature
Taste & odor
Bacteria
Phosphorus
Toxics
Temperature
Dissolved oxygen
pH
Phosphorus
Toxics


Primary producers
Primary consumers
Secondary consumers
Ecosystem effects
Detritus feeders
Destruents
Shredders
Specific modes of action


12
1
8
6
4
2
0
Number of dead fish
96 h-LC50 of CdCl2 was 7.1 mg/ L
20
15
10
5
1
0.5
0
Concentration of CdCl2 mg/ L-1