Department of Environmental Health and Science

College of Science

University of Salahaddin-Erbil

Subject: Water Pollution

Course Book – (3rd Year)

Lecturer's name Prof. Dr. Yahya Ahmed Shekha

Lanja Omer Tahir (Lecturer) Practical

Academic Year: 2023/2024

Course Book

1. Course name	**Water Pollution**
2. Lecturer in charge	**Dr. Yahya A. Shekha** **Lanja Omer Tahir**
3. Department/ College	**Environmental Science and Health- Science**
4. Contact	**e-mail: yahya.shekha@su.edu.krd** **e-mail: lanja.tahir@su.edu.krd**
5. Time (in hours) per week	**For example Theory: 2 hrs.** **Practical: 2*2 (Supervision)**
6. Office hours	**Every day 9- 12 am except the day off**
7. Course code	
8. Teacher's academic profile	**I was accepted in Salahaddin University 1988- 1989 as a student in BSc and graduated in 1991- 1992. Directly I accepted in MSc studies in 1992 and completed it in 1995 in specialization Environmental Microbiology (Aquatic microbiology), for ten years served as an assistant lecturer in the Biology Department/ College of Science, I teach under and postgraduate students all subjects related to the environment to biology student, I attained Lecturer degree in 2003. Accepted in Biology Department- College of Science- Baghdad University 2004 for Ph.D. studies, completed it in 2008 in Ecology and Pollution (Invertebrate Ecology and Aquatic Microbiology), attained assistant Prof. in 2009 and Professor degree in 2017. I published more than 50 manuscripts in local and international Journals, participated in local conferences and workshops, till now graduated six MSc students and 2 Ph.D. students, and I have other two MSc students and 1 Ph.D. student.**
9. Keywords	**Environment, air, water, pollution, human health**

10. Course overview:

In this course, students will learn about water pollution sources related to environmental degradation. Furthermore, they will learn about the ecosystems of Erbil city and familiarize themselves with various anthropogenic activities that are posing a threat to the existence of these aquatic ecosystems, and how these ecosystems can be preserved. Students will also learn about the ways by which water resources will be affected by various contaminants either physical or chemical or biological origins. In addition, it could be followed in different ways to reduce, combat, or control water pollution.

11. Course objective:

Water Pollution become one of the most important subjects for all communities categories, it, directly and indirectly, affects human life, so it is important to study this subject for the following reasons: teach the students all information about water, its components, constituents, living and non-living things in this aquatic ecosystems and the balance between the component in virgin or in a clean environment, then known about all types of pollutant that may be physical, chemical or biological, or it may be from natural or artificial sources, or it may

come from urban, industrial, agriculture source, then and how it may be effect on human being, what is the guidelines for these pollutant, their safe ranges for human, animal or plant life.

Teach students how to protect the aquatic ecosystems from pollutant and pollution sources, conserve and restore the environment, and put legislation and laws for each topic, to control the level of pollution in a different environment.

Awareness is another point that should be taken into account in this subject to teach even the community about the importance of the environment and keep them clean with references to pollution's impact on our life activities.

12. Student's obligation

The attendance of the students in the hall is the most important thing for the lecturer because it is the way to collect information for students, then participate with the students through lecture time by asking them, known their background, conversation, homework, quizzes, report, etc.

13. Forms of teaching

Different forms of teaching will be used to reach the objectives of the course: PowerPoint presentations for the head titles and definitions and summary of conclusions, description of the types of pollution and their sources, and any other illustrations, besides Worksheets will be designed to let the chance for practicing on several aspects of the course in the classroom.

Graduate students will be required to review a scientific paper that relates to one of the course topics. The review will consist of a paper that is at a maximum of five pages (typed) in length and an oral presentation of the review (15 minutes in length). The goal is to have each student relate to the types and sources of environmental pollution. The format for the paper and presentation will be discussed in class.

14. Assessment scheme

Lecture Exams (4 x 100 Points)	400 Points
Attendance, quizzes, report, home works	100 Points
Total	500 Points

Mean of four examinations and others activities: 15%

Practical Examination 35%

Final examination: 50%

15. Student learning outcome:

Environmental pollution is the most important subject in our community because it has a direct relation to our life, authority, and NGOs and all companies give special importance to this subject. Student through studies in this course which cover all aquatic ecosystems properties, pollutants, sources, effects, controlling, guidelines, conservation, restoration, well attended good information and knowledge about pollution then can be used or applied in future during their work.

16. Course Reading List and References:

1- Yael Calhoun. (2005). Water Pollution. 1st Ed. Chelsea House Publishers.
2- Suresh T. Nesaratnam. (2014). Water pollution control. John Wiley & Sons Ltd.
3- Satinder Ahuja. (2013). Monitoring Water Quality: Pollution Assessment, Analysis, and Remediation. Elsevier. UK.

17. The Topics:	Lecturer's name
Week one: **Understanding water pollution.**	
Week Two: Sources of water pollution	
Week Three: **Oil spills.**	
Week Four: **Thermal pollution**	
Week Five: **Organisms as biological indicators.**	
Week Six: **Biodegradation (Aerobic and anaerobic decomposition).**	
Week Seven: Examination	
Week Eight: **Effect of pollution on different aquatic ecosystems.**	
Week Nine: **Groundwater pollution.**	
Week Ten: **Specific phenomena related to water pollution- Algal bloom, Eutrophication.**	
Week Eleven: **Self- purification**	
Week Twelve: **Metals pollution**	
Week Thirteen: **Pathogenic organisms contaminated water sources**	
Week Fourteen: Examination	
18. Practical Topics	
▪ Determination of color and Turbidity ▪ Biochemical Oxygen Demand (BOD_5^{20}) ▪ Chemical Oxygen Demand (COD) ▪ Nitrite, Nitrate, Organic Nitrogen and Total Nitrogen ▪Determination of Nitrogen (Ammonia) ▪First practical examination ▪ Determination of orthophosphate (PO_4) ▪ Determination of Sulphate (SO_4^{-2}) ▪ Determination of heavy metals by atomic Absorption ▪ Determination of Oil and greases ▪ Algae as organic pollution indicators ▪Second practical examination ▪ Detection of microorganisms ▪ Insects as water pollution indicators ▪Presentation seminar by students	

19. Examinations:

Q1/ **Discuss the following: (Choose only *five*)** **(15 Marks)**

1. **How you can deal with oil spills?**
2. **What are the sub-lethal effects of elevated heavy metals on aquatic organisms?**

3. **What are the most important approaches to studying biological indicators?**
4. **Ecological effects of warm water.**
5. **The role of microorganisms and fauna on self-purification.**
6. **What is anaerobic biodegradation?**
7. **How do you combat the Symptoms of Eutrophication?**

Q2/ **Define the following: (Choose only *ten*) (10 Marks)**

1. Mousse 2. Indicator organisms 3. Thermal shock 4. Polysaprobic zone 5. Eutrophication 6. Algal blooming 7. Emulsification 8. Red tide 9. Thermal enrichment 10. Synergism 11. Cogeneration 12. Arsenicosis

Q3/ **Fill the following blanks with the correct word: (10 Marks)**

1. **……. and …….. are the specific skin lesions that indicate chronic arsenic toxicity.**
2. **The most important methods for treating eutrophication are……, ……., …….. and…….**
3. **……. and …….. are the most common algae used as indicator species used for organic pollution studies according to Palmer's list. The most tolerant species is ……**
4. **Heavy metals are metallic elements that have a relatively high density……..**

Q4/ **Illustrate two of the following by sketching: (10 Marks)**

1. **Differences in intolerance of invertebrate groups to organic pollution?**
2. **Sources of heavy metals contamination in the aquatic ecosystem?**
3. **Eutrophication.**

Q5: Only enumerate the following: (Choose only one) (5 Marks)

1. The topics that are used for studying environmental stress responses by macroinvertebrates.

2. The most common anthropogenic and natural pollution sources on groundwater.

Typical Answers:

1. **Dealing with oil spills:**

Strategies for dealing with oil pollution once it has occurred have not been very effective and some such as hot water washing may do more harm than good. The failures include using detergents to disperse oil that can do more harm than the oil and using absorbents like straw to hold the oil, creating a new disposal problem. Burning the oil is usually not very effective because flammable materials escape quickly and

leave the more fire- resistant chemicals behind. Various new containment methods are being tried and tested, for example, deploying barriers that contain the oil so that it can be siphoned up, skimmed off, or recovered in some other way. In general, all of these approaches have proved ineffective.

Some of the latest methods being considered include the use of microorganisms that can degrade oil. Some natural microorganisms degrade oil, and others have been genetically engineered to do so. The addition of fertilizer containing the limiting nutrients nitrogen and phosphorus is effective in accelerating the growth of the naturally occurring microorganisms and hence the degradation of oil. This use of fertilizer succeeds in cleaning some of the shoreline after the Exxon Valdez spill. Further investigation is needed to see if the bacteria actually consumed the oil or simply loosened it to be washed back into the water. Preliminary data showed no adverse impact on the aquatic environment due to over fertilization.

It is clear, however, that the best way to deal with this problem is to prevent it from happening in the first place. This can be done by better enforcement of regulations governing bilge- pumping and tanker-cleaning operations, better control of loading and uploading operations, maintenance and controls in the construction of supertankers, better training of tanker crews, better training and methods for managing offshore drilling rigs, and better regulation of aboveground storage tanks.

2.

The slightly elevated metal levels in natural water may cause the following sub-lethal effects in aquatic organisms:
1- Histological or morphological change in tissues.
2-Changes in physiology, such as suppression of growth and development and poor swimming performance
3- Change in biochemistry, such as enzyme activity and blood chemistry.
4- Change in behavior.
5- Changes in reproduction.

3. Two main approaches have been used: methods based on community structure and methods based on “indicator” organisms. An indicator organism is a species selected for its sensitivity or tolerance (more frequently sensitivity) to various kinds of pollution or its effects, e.g. metal pollution or oxygen depletion. Some groups of organisms, such as benthic invertebrates, have been exploited more than others in the development of ecological methods and this is due to a combination of the specific role of the organisms within the aquatic environment.

4. Ecological effects — warm water:

It is known that temperature changes of even one to two degrees Celsius can cause significant changes in organism metabolism and other adverse cellular biology effects. Principal adverse changes can include rendering cell walls less permeable to necessary osmosis, coagulation of cell proteins, and alteration of enzyme metabolism. These cellular level effects can adversely affect mortality and reproduction.

Primary producers are affected by warm water because higher water temperature increases plant growth rates. This can cause an algae bloom which reduces the oxygen levels in the water. The higher plant density leads to an increased plant respiration rate because the reduced light intensity decreases photosynthesis. This is similar to the eutrophication that occurs when watercourses are polluted with leached agricultural inorganic fertilizers.

A large increase in temperature can lead to the denaturing of life-supporting enzymes by breaking down hydrogen- and disulphide bonds within the quaternary structure of the enzymes. Decreased enzyme activity in aquatic organisms can cause problems such as the inability to break down lipids, which leads to malnutrition.

5. The general response of stream invertebrate animals to partially stabilized municipal wastewater is illustrated in Figure (part D). Decomposition of the organic matter and nitrification of ammonia result in uptake of dissolved oxygen by bacteria and protozoa, even if chlorination of the effluent temporarily depletes these microbial populations Figure (part B). If the dilution flow is inadequate. Massive colonies of fungi, filarnentous bacteria, and stalked protozoa create ragged white- and' brown-colored growths on solid objects in the stream and can even form a carpet over the mud bottom Figure (part C). As the dissolved oxygen concentration sags, the variety of animal's decreases and the numbers of those surviving rise sharply. Clean-water invertebrates disappear if overcome by toxins and lack of oxygen. Their replacements are pollution invertebrates consisting largely of sludge and blood worms that thrive in the organic matter blanketing the bottom. Referring to these as pollution organisms is not entirely proper since they are normal inhabitants of river mud: however, they are favoured by organic pollution. Fish are repelled by the ad verse environment and may be killed if they cannot escape or tolerate these conditions. In either case, the normal diversity of fish species does not reappear until a suitable habitat for reproduction and feeding is reestablished downstream.

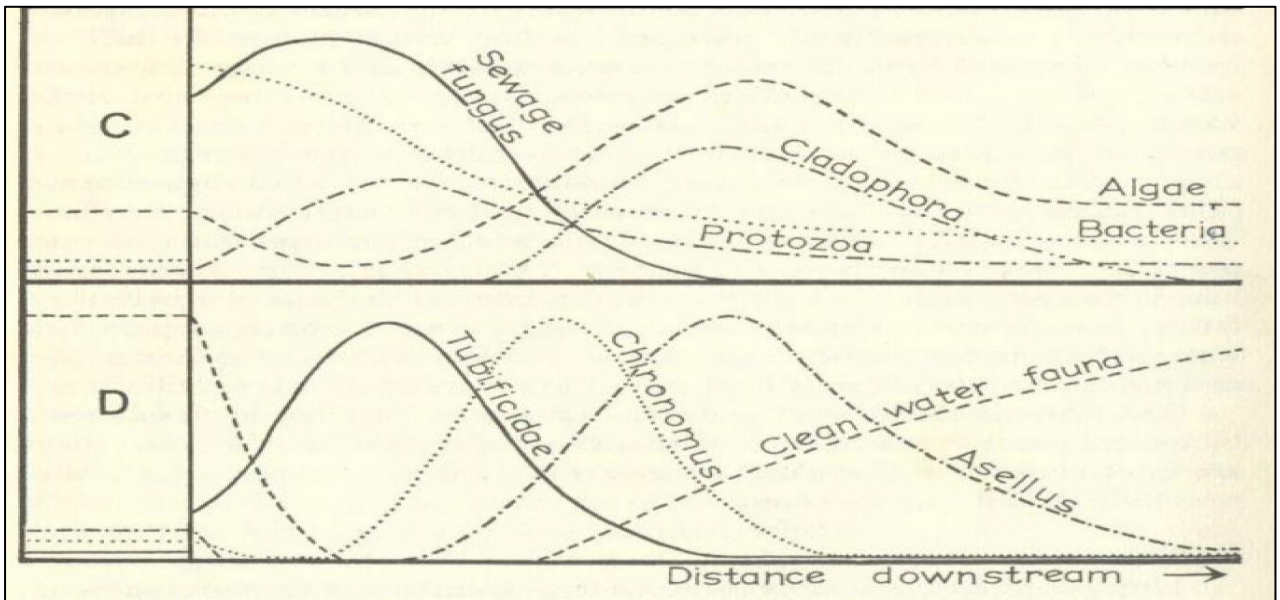


FIG. 16. Diagrammatic presentation of the effects of an organic effluent on a river and the changes as one passes downstream from the outfall. A & B physical and chemical changes, C Changes in micro-organisms, D Changes in larger animals.

6. Anaerobic decomposition is performed by a completely different set of microorganisms, to which oxygen is toxic. The basic equation for anaerobic biodegradation is:

$$C_xH_yN_z \longrightarrow CO_2 + CH_4 + NH_3 + \text{partly stable compounds}$$

Many of the end products of the reaction are biologically unstable. Methane (CH_4), for example, a high-energy gas commonly called marsh gas, is physically stable but can be decomposed biologically. Ammonia (NH_3) can be oxidized, and sulfur is anaerobically biodegraded to evil-smelling sulfhydryl compounds like hydrogen sulfide (H_2S).

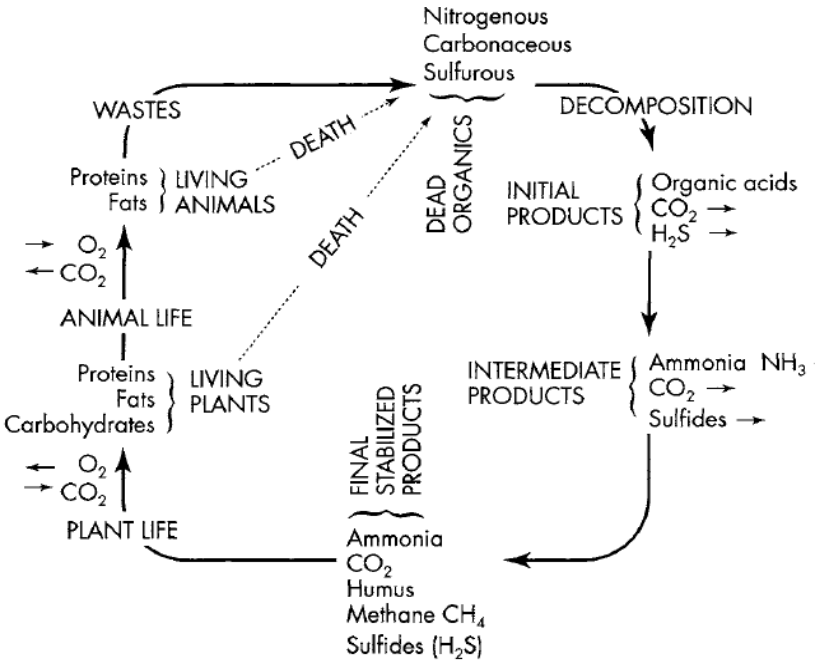


FIGURE 3–4. Anaerobic nitrogen, carbon, and sulfur cycles. [Adapted from McGauhey, P.H., *Engineering Management of Water Quality*, New York: McGraw-Hill (1968).]

7. **Combating the Symptoms of Eutrophication:**

There are two approaches to combating the problem of eutrophication. One is to attack the symptoms—the growth of vegetation or the lack of dissolved oxygen or both. The other is to get at the root cause—

excessive inputs of nutrients and sediments. Attacking the symptoms has application in certain situations where immediate remediation is the goal and costs are not prohibitive. But consider the longer-term efficacy of such methods if the causative inputs are not curtailed. Attacks on the symptoms include (1) **chemical treatments**, (2) **aeration**, (3) **harvesting aquatic weeds**, and (4) **dredging**.

Chemical Treatments:

Phytoplankton—especially the cyanobacteria, which are the most obnoxious—are among the most resistant of all organisms. Therefore, amounts of chemicals sufficient to kill them also have severe effects on virtually all other aquatic organisms. No chemical has been found that will selectively kill phytoplankton and not harm other aquatic plants and animals. Nevertheless, copper sulfate is currently being used to control the growth of phytoplankton in some water-supply reservoirs, where they would otherwise impart a bad taste to the water and cause excessive clogging of filters.

Aeration:

An aeration system currently gaining popularity is to lay a network of plastic tubes with microscopic pores on the bottom of the waterway to be treated. High pressure air pumps force from the pores micro-bubbles that dissolve directly into the water. (Larger bubbles would simply rise to the surface, wasting most of the pumped air.) The system is proving effective in speeding up the breakdown of accumulated detritus, improving water quality, and enabling the return of more desirable aquatic life.

Harvesting:

Commercial mechanical harvesters are used, and nearby residents also have gotten together to remove the vegetation by hand. The harvested vegetation makes good organic fertilizer and mulch. But even harvesting has a limited effect. The vegetation soon grows back because roots are left in the nutrient-rich sediments. Mechanically removing phytoplankton is not at all practical. The microscopic cells would have to be filtered from the water.

Dredging:

Dredging may be required to remove sediments blocking access for boating or shipping. Dredging, however, tends to increase eutrophication because it invariably stirs much settled material back into solution where it increases turbidity and stimulates the growth of phytoplankton. There is also a significant problem in finding a suitable place to dispose of the dredged material.

A2:

1. **Mousse:** when oil spills to seawater some of the compounds in the oil evaporate, the oil gets thicker, waves batter this viscous oil into a thick water and- oil emulsion called mousse.
2. **Indicator" organisms**: An indicator organism is a species selected for its sensitivity or tolerance (more frequently sensitivity) to various kinds of pollution or its effects.
3. When a power plant first opens or shuts down for repair or other causes, fish and other organisms adapted to particular temperature range can be killed by the abrupt rise in water temperature known as **'thermal shock'**
4. **Polysaprobic zone (extremely severe pollution):** Rapid degradation processes and predominantly anaerobic conditions. Protein degradation products, peptones and peptides, present. Hydrogen sulphide (H_2S), ammonia (NH_3) and carbon dioxide (CO_2) are produced as the end products of degradation. Polysaprobic waters are usually dirty grey in colour with a faecal or rotten smell, and highly turbid due to the enormous quantities of bacteria and colloids.

5. Eutrophication: the nutrient enrichment allows the rapid growth and multiplication of phytoplankton, causing increasing turbidity of the water. The increasing turbidity shades out the submerged aquatic vegetation (SAV). Even where light continues to penetrate to the bottom, the photosynthesis of benthic vegetation may be blocked because its leaves and stems become coated with epiphytic algae growing in the nutrient rich-water.

6. Algal blooming:

A microbial (algae and cyanobacteria) "bloom" is not a flower. The term refers to a sudden burst of phytoplankton growth in surface waters in otherwise oligotrophic lakes. Microbial blooms typically occur in the spring and fall in lakes in temperate regions. Such blooms may be so intense that the water appears greenish, but they typically last only a week or two and then subside. Of course, as a body of water becomes enriched with nutrients, blooms become more intense and last longer until them may last the whole growing season.

7. **Emulsification:** About 24 hours after oil spill, oil and seawater occurs. This is an especially significant event because a sticky, viscous material is formed that adheres to everything with which it comes in contact- fish, birds, mammals, shorelines.
8. **Red tide:** Among the many species of phytoplankton found in the oceans are some that are reddish and give rise to' extremely toxic byproducts. Blooms of this phytoplankton are responsible for infamous red tides. Their numbers literally turn the water reddish, and fish, s mammals, and other organisms unfortunate enough to be within the area of the bloom are killed by their toxic byproducts—a biotoxin, Like natural phytoplankton blooms in otherwise oligotrophic lakes, red tides have been observed far back in history. However, in the past decade both the locations and frequency of such events have increased dramatically.

9. In limited cases, warm water has a little deleterious effect and may even lead to improved function of the receiving aquatic ecosystem. This phenomenon is seen especially in seasonal waters and is known as **thermal enrichment**.
10. The combined effects of two or more pollutants are more severe or even qualitatively different from individual effects of separate pollutants a phenomenon known as **synergism.**

11. **Cogeneration:** a process where waste heat is recycled for domestic and/or industrial heating purposes.

12. Arsenic toxicity can be either acute or chronic and chronic arsenic toxicity is termed **arsenicosis**. Pigmentation and keratosis are the specific skin lesions that indicate chronic arsenic toxicity

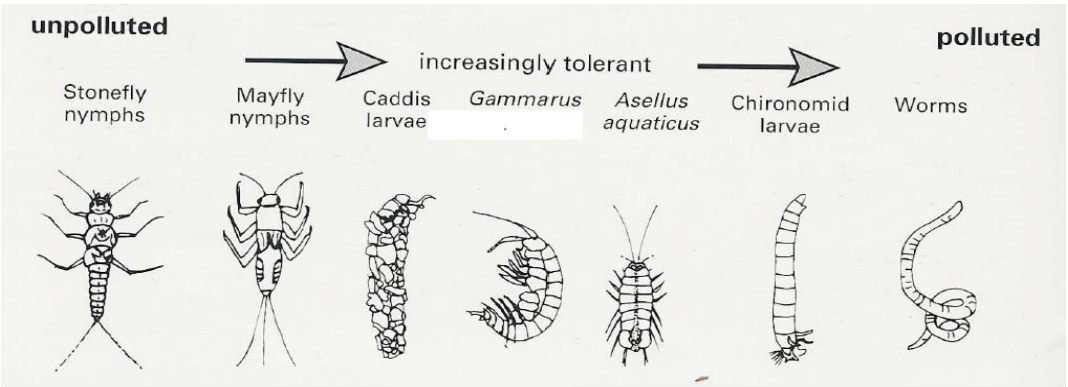
A3:

1. **Pigmentation** and **keratosis**
2. **Chemical treatments**, **aeration**, **harvesting aquatic weeds**, and **dredging**

3. **Nitzchia** and **Oscillatoria** or ….., **Palmar**.
4. more than **5 g/cm^3** .

A4:

1.



Differences in tolerance of invertebrate groups to organic pollution

2.

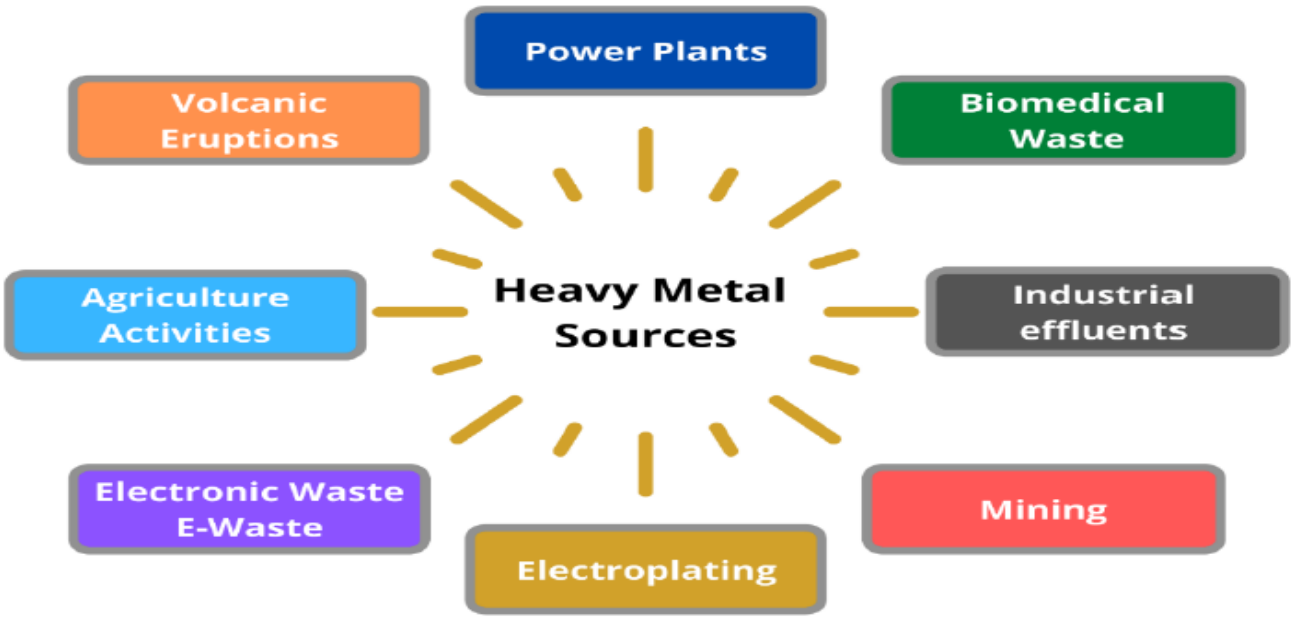
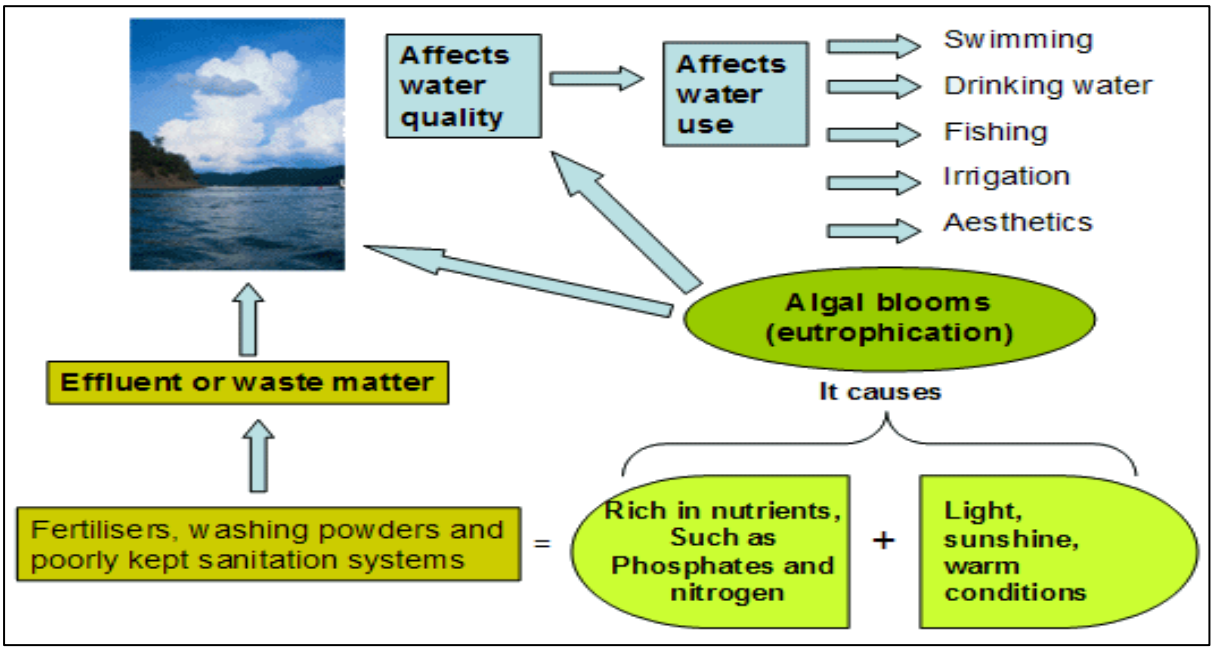


Figure 1. Diffrent sources of contamination heavy metal in water & aquaculture.

3.



A5:

1. **Macroinvertebrates respond to environmental stress:**

• Oxygen depletion
• Direct toxicity
• Loss of microhabitat
• Siltation of habitat
• Food availability changes
• Competition from other species.

2. ***Anthropogenic and Natural Pollution Sources on groundwater pollution:***

The most common pollution sources are anthropogenic ones. This category generally includes:
• The disposal of wastewater and solid waste,
• The disposal of industrial wastewater,
• The use of fertilizers, pesticides, and insecticides,
• The by-products and waste from mining activities,
• The disposal of nuclear energy waste.

20. Extra notes:

Here the lecturer shall write any note or comment that is not covered in this template and he/she wishes to enrich the course book with his/her valuable remarks.

21. Peer review

پێداچوونەوەی هاوەڵ

This course book has to be reviewed and signed by a peer. The peer approves the contents of your course book by writing few sentences in this section.

(A peer is person who has enough knowledge about the subject you are teaching, he/she has to be a professor, assistant professor, a lecturer or an expert in the field of your subject).

ئەم کۆرسبووکە دەبێت لەلایەن هاوەڵێکی ئەکادیمیەوە سەیر بکرێت و ناوەڕۆکی بابەتەکانی کۆرسەکە پەسەند بکات و جەند ووشەیەک بنووسێت لەسەر شیاوی ناوەڕۆکی کۆرسەکە و واژووی لەسەر بکات.

هاوەڵ ئەو کەسەیە کە زانیاری هەبێت لەسەر کۆرسەکە و دەبیت پلەی زانستی لە مامۆستا کەمتر نەبێت.