Model answers
M.Sc-IV-Botany
Specialization: Pollution Ecology
LBT 402: Water Pollution Management (AR-7170)

Section A. Multiple Choice/very short answer/ Fill in the Blanks

1. (a)
2. (a)
3. (d)
4. (d)
5. Central Water Commission
6. National Ganga River Basin Authority
7. Ministry of Environment and Forest
8. Chemical oxygen demand
9. Nitrogen (N)…. and…..Phosphorous (P)
10. ..Point.

Section B. Long answer type questions

1. **Short notes on**

(a) Physicochemical properties of Sewage

Physical Characteristics of Sewage:

The physical characteristics of wastewater include those items that can be detected using the physical senses. They are temperature, color, odor, and solids.

Temperature

Temperature of wastewater varies greatly, depending upon the type of operations being conducted at your installation. Temperature of sewage the sewage is slightly more than that of water, because of the presence of industrial sewage. The temperature changes when sewage becomes septic because of chemical process. The lower temperature indicates the entrance of ground water into the sewage.

Color; of fresh sewage is yellowish grey to light brown. While that of the septic is black or dark due to oxidation of organic matter.

Odor; smell of the fresh sewage is oily or soapy while the septic sewage develops an objectionable. H_2S is the major source of pollution.

Solids

all matter except the water contained in liquid materials is classed as solid matter. The usual definition of solids, however refers to; "the matter that remain as residual upon evaporation and drying at 103 ± 20C".

Those solids that are not dissolved in wastewater are called **suspended solids**. When suspended solids float, they are called floatable solids or scum. Those suspended solids that settle are called **settleable solids, grit, or sludge**.

All solids that burn or evaporate at 500°C to 600°C are called **volatile solids**. These solids serve as a food source for bacteria and other living forms in a wastewater treatment plant. Most organic solids in municipal waste originate from living plants or animals.

Those solids that do not burn or evaporate at 500°C to 600°C, but remain as a residue, are called fixed solids. Fixed solids are usually inorganic in nature and may be composed of grit, clay, salts, and metals.

Turbidity

The term "turbid" is applied to water/wastewater containing suspended matter or in which the visual depth is restricted.

Chemical Characteristics of Sewage (Wastewater)

Sewage contains both organic and inorganic chemicals in addition to various gases like H_2S, CO_2, CH_4, and NH_3 etc that are formed due to the decomposition of sewage. The chemical characteristics of wastewater of special concern are pH, DO (dissolved oxygen), oxygen demand, nutrients, and toxic substances.

PH

PH is used to describe the acid or base properties of water solutions. The pH of sewage is initially high and drops when the sewage becomes septic but becomes increases again with the treatment processes.

Dissolved oxygen (DO)

Wastewater that has DO is called aerobic or fresh. The solubility of oxygen in fresh water ranges from 14.6 mg/L at 0^oC to about 07 mg/L at 35^oC at 1.0 atm. pressure.

Oxygen Demand

It is the amount of oxygen used by bacteria and other wastewater organisms as they feed upon the organic solids in the wastewater.

BOD

BOD is defined as the amount of oxygen required by the bacteria while stabilizing decomposable organic matter under aerobic condition. It is written as by BOD or BOD520. “It is the amount of oxygen required by aerobic bacteria to decompose/stabilized the organic matter at a standard temperature of 20oC for a period of 05 days”. For domestic sewage 05 days BOD represents approx. 2/3 times of demand for complete decomposition.

COD

By definition the COD is the amount of oxygen required to stabilized the organic matter chemically, i.e. the COD is used as a measure of the oxygen equivalent of the organic matter contents of a sample that is susceptible to oxidation by a strong chemical oxidant.

Nutrients

Are life-supporting nitrogen and phosphorus.

Toxic Chemicals; most industrial use various types of toxic chemicals, the discharges of which can be harmful to wastewater treatment processes.

(b) Macro-invertebrates as Bioindicator of water quality

- Biological water quality monitoring involves collecting samples of aquatic macroinvertebrates. Aquatic macroinvertebrates live in water for at least part of their life cycle. They include insects, worms, snails, mussels, leeches, and crayfish. For the purpose of assessing water quality, sampling is focused on benthic macroinvertebrates, those organisms that live at the stream bottom.
- These organisms are easy to collect and identify, and tend to stay in one area unless environmental conditions change. Some macroinvertebrates are highly sensitive to pollution, while others tolerate it.

Aquatic Macroinvertebrates – Highly Sensitive to Pollution

Certain macroinvertebrates serve as bioindicators of good water quality. These organisms tend to require high dissolved oxygen levels. When present in large numbers, these macroinvertebrates suggest the stream is in good condition. If these organisms were once abundant, but subsequent sampling shows a decline in numbers, it may indicate that a pollution incident occurred. These organisms include:

:

- mayfles (nymphs)
- riffle beetles (adults)
- caddisflies (larvae)

- stoneflies (nymphs)
- water pennies
- gilled snails
- hellgrammites (dobsonfly larvae)

Aquatic Macroinvertebrates – Somewhat Tolerant of Pollution

This group of macroinvertebrates tends to tolerate some degradation of water quality. Their abundance and diversity indicates a stream is in fair to good condition. These macroinvertebrates include:

- alderflies (larvae)
- dragonflies and damselflies (nymphs)
- whirligig beetles (larvae)
- riffle beetles (larvae)
- fishflies (larvae)
- sowbugs
- scuds
- crayfish
- clams
- mussels

Aquatic Macroinvertebrates – Pollution Tolerant

Certain macroinvertebrates thrive in poor quality water. An abundance of these organisms suggests environmental conditions in a stream have deteriorated. Some of these invertebrates use "snorkels" to access oxygen at the water's surface, and are less dependent on dissolved oxygen to breathe. These macroinvertebrates include:

- black flies (larvae)
- midge flies (larvae)
- lunged snails
- aquatic worms
- leeches

Ans. Q.2. Short notes on

(a) Fishes as bioindicator of water quality

A bioassessment conducted using a fish assemblage requires that all fish species (and size Classes), not just game fish, be collected. Fish are good indicators of long-term effects and broad habitat conditions because they are relatively long-lived and mobile. The fish assemblage also integrates various features of environmental quality, such as food and habitat availability. The physical degradation of streams can cause changes in the food web and the composition and distribution of habitats.

The objective of the fish assemblage portion of any protocol is to collect a representative sample using methods designed to (a) collect all except rare species in the assemblage and (b) provide a measure of the relative abundance of species in the assemblage. Also, fish diversity is low naturally in headwaters and other small streams, as well as in intermittent streams, making fish less viable indicators than other assemblages. Fish are considered important indicators in larger water-body. types (e.g., lakes, estuaries); However, here too, fish assemblages have been used less often than other methods in water quality assessments because of mobility and sampling difficulties in these water bodies.

All fish species should be identified to species level either in the field or the laboratory,. As with benthic macroinvertebrates, it is important to retain voucher specimens (ideally in a museum or university).

EPA recommends that a taxonomic expert verify and make determinations on any problematic taxa. Additional information on species of interest may be obtained by recording total length and weight. In addition, fish may be examined for external anomalies.

- For the toxic chemicals, main indicator organ in fish is liver, because it accumulates harmful compounds. liver enzymes are used as biomarkers of liver damage.
- concentration of metallothionein in liver is used as specific biomarker of metal exposure.

(b) Water pollution sources

Based on different criterial, the sources can be divided as follows

(1) Based on location

(i) Point sources

It refers to contaminants that enter a waterway from a single, identifiable source, such as a pipe. Examples of sources in this category include discharges from a sewage treatment plant, a factory, or a city storm drain.

(ii) Non-point sources

It refers to diffuse contamination that does not originate from a single discrete source. It is often the cumulative effect of small amounts of contaminants gathered from a large area. Examples: (1) leaching out of nitrogen compounds from fertilized agricultural lands. (2) Nutrient runoff in stormwater from "sheet flow" over an agricultural field or a forest are also cited as examples of NPS pollution (3) Contaminated storm water washed off of parking lots, roads and highways, called urban runoff, is sometimes included under the category of NPS pollution.

(1) Based on physical/chemical/bilogical property

(i) Organic chemicals

- Detergents & Disinfection by-products found in chemically disinfected drinking water, such as chloroform
- Food processing waste, which can include oxygen-demanding substances, fats and grease
- Insecticides and herbicides, a huge range of organohalides and other chemical compounds
- Petroleum hydrocarbons, including fuels (gasoline, diesel fuel, jet fuels, and fuel oil) and lubricants (motor oil), and fuel combustion byproducts, from stormwater runoff
- Tree and bush debris from logging operations
- Volatile organic compounds (VOCs), such as industrial solvents, from improper storage.
- Chlorinated solvents, which are dense non-aqueous phase liquids (DNAPLs), may fall to the bottom of reservoirs, since they don't mix well with water and are denser.
- Polychlorinated biphenyl (PCBs)
- Trichloroethylene
- Perchlorate
- Various chemical compounds found in personal hygiene and cosmetic products.

(ii) In-organic chemicals

- Acidity caused by industrial discharges (especially sulfur dioxide from power plants)
- Ammonia from food processing waste
- Chemical waste as industrial by-products
- Fertilizers containing nutrients--nitrates and phosphates—which are found in stormwater runoff from agriculture, as well as commercial and residential use
- Heavy metals from motor vehicles (via urban stormwater runoff) and acid mine drainage
- Silt (sediment) in runoff from construction sites, logging, slash and burn practices or land clearing sites.

(iii) Macroscopic pollution—large visible items polluting the water—may be termed "floatable" in an urban stormwater context, or marine debris when found on the open seas, and can include such items as:

- Trash or garbage (e.g. paper, plastic, or food waste) discarded by people on the ground, along with accidental or intentional dumping of rubbish, that are washed by rainfall into storm drains and eventually discharged into surface waters
- small ubiquitous waterborne plastic pellets
- Shipwrecks, large derelict ships.

(iv) Biological contaminants

Coliform bacteria are a commonly used bacterial indicator of water pollution, although not an actual cause of disease. Other microorganisms sometimes found in surface waters which have caused human health problems include:

- *Burkholderia pseudomallei*
- *Cryptosporidium parvum*
- *Giardia lamblia*
- *Salmonella*
- *Novovirus* and other viruses
- Parasitic worms (helminths).

High levels of pathogens may result from inadequately treated sewage discharges. This can be caused by a sewage plant designed with less than secondary treatment (more typical in less-developed countries). In developed countries, older cities with aging infrastructure may have leaky sewage collection systems (pipes, pumps, valves), which can cause sanitary sewer overflows. Some cities also have combined sewers, which may discharge untreated sewage during rain storms.

(v) Thermal pollution

A common cause of thermal pollution is the use of water as a coolant by power plants and industrial manufacturers. Elevated water temperatures decreases oxygen levels, which can kill fish, and can alter food chain composition, reduce species biodiversity, and foster invasion by new thermophilic species. Urban runoff may also elevate temperature in surface waters.

Thermal pollution can also be caused by the release of very cold water from the base of reservoirs into warmer rivers.

Ans 4. Role of pollution control boards in water pollution control in India

Central Pollution Control Board in collaboration with concerned SPCBs/PCCs established a nationwide network of water quality monitoring comprising 1019 stations in 27 States and 6 Union Territories. The monitoring is done on monthly or quarterly basis in surface waters and on half yearly basis in case of ground water. The monitoring network covers 200 Rivers, 60 Lakes, 5 Tanks, 3 Ponds, 3 Creeks, 13 Canals, 17 Drains and 321 Wells. Among the 1019 stations, 592 are on rivers, 65 on lakes, 17 on drains, 13 on canals, 5 on tanks, 3 on creeks, 3 on ponds and 321 are groundwater stations.

The main function of the Pollution Control Board is to promote cleanliness of water bodies and to prevent pollution.

- If may also perform the following functions:
- Advise the Government on prevention and control of pollution.
- Carry out and encourage investigations and research relating to pollution problems.
- Plan and organize training programmes for persons involved in prevention and control of pollution.
- Organize through mass media, a comprehensive programme regarding pollution and control.
- Collect, compile and publish technical and statistical data, manuals, codes and guides.
- Establish or recognize laboratories for analyzing pollution parameters.
- Advise the Government regarding the suitability of any site for the location of industry.
- Issue environmental no objection certificate to start an industry.
- Inspect and review sewage or industrial effluent treatment plants and to grant consent.
- Prescribe effluent quality standards and the quality of receiving waters resulting from the discharge of effluents.
- Evolve economical and reliable methods of treatment, utilization, and disposal of sewage and industrial effluent with regard to soil, climate and water resources of the region under consideration.
- Monitor the compliance of the standards regarding ground water & leachate quality.
- Close down a defaulting industrial plant or withdraw its supply of power or water.

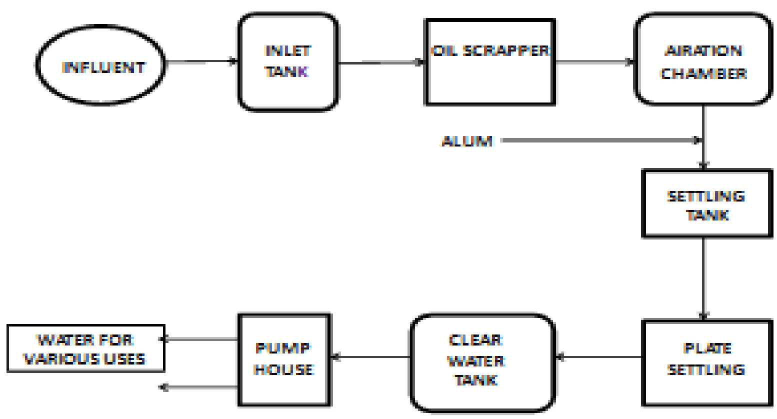
Ans. 5. Treatment of effluent generated from thermal power plants

Waste water from thermal power plants includes waste water from water purifiers, waste water from fuel oil pump rooms which is likely to contain oil, water from flue gas desulfurizing facility, domestic waste water from kitchen and sanitation. The major ingredients of such waste water range from acidic and alkaline substances to suspended solids, oil, and soluble iron. In thermal power plants, waste water from all equipment is collected at one place and subjected to treatment by high-performance oil separator and coagulating sedimentation. Waste water treatment system in thermal power plants is thus integrated.

When waste water is known to contain oil, it is sent to high performance oil separators such as the PPI (Parallel Plate Interceptor) and CPI (Corrugated Plate; Interceptor). With oil separated there, water is subsequently passed through a number of filters, consisting of sand, oil adsorbent and active carbon, so as to separate trace amounts of oil, suspended solids, and so on.

Waste water from water purifier and waste water from flue gas desulfurizing facility are temporarily held in storage tanks. These are treated in a neutralizing system, coagulating and sedimentation system to neutralize acids and alkali, and to remove suspended solids and soluble iron.

Among the liquid effluents generated in the plant, the major quantities come from cooling tower blow down. Major pollutants can be suspended solids and others like chlorine, zinc, chromium and phosphate. Boiler blow down is done to control dissolved solids in boiler water. ETP consist of oil scrapper, plate settling, aeration chamber, chemical mixing, to separate oil and suspended solids. A schematic of treatment of waste water generated in a typical TPP is shown below



The various sources of the effluent are boiler blow downs, cooling tower blow downs, waste water from fly ash and bottom ash evacuation system, various drains etc. The effluent generated in the plant is collected in the intake tank of the central effluent treatment plant. The oil scrapers are provided to remove the oil contamination. The effluent is then pumped to the aeration chamber followed by settling tank and plate settling. The clear water is collected in the clear water tank. This water is then reused for various purposes such as cleaning, gardening and AHP.

Ans 6. Role of National Ganga River Basin Authority (NGRBA) is stream water pollution management in India.

National Ganga River Basin Authority (**NGRBA**) is a financing, planning, implementing, monitoring and coordinating authority for the Ganges River, functioning under the Ministry of Environment of India. The mission of the organization is to safeguard the drainage basin which feeds water into the Ganges by protecting it from pollution or overuse.

It was established by the Central Government of India, on 20 February 2009 under Section 3(3) of the Environment Protection Act, 1986, which also declared Ganges as the "National River" of India.

The objective of the NGRBA is to ensure effective abatement of pollution and conservation of the river Ganga by adopting a river basin approach for comprehensive planning and management The Authority has both regulatory and developmental functions. The Authority will take measures for effective abatement of pollution and conservation of the river Ganga in keeping with sustainable development needs. These include:

- Development of a river basin management plan
- Regulation of activities aimed at prevention, control and abatement of pollution in Ganga to maintain its water quality, and to take measures relevant to river ecology and management in the Ganga basin states;
- Maintenance of minimum ecological flows in the river Ganga;
- Measures necessary for planning, financing and execution of programmes for abatement of pollution in the river Ganga including augmentation of sewerage infrastructure, catchment area treatment, protection of flood plains, creating public awareness;
- Collection, analysis and dissemination of information relating to environmental pollution in the river Ganga;
- Investigations and research regarding problems of environmental pollution and conservation of the river Ganga;
- Promotion of water conservation practices including recycling and reuse, rain water harvesting, and decentralised sewage treatment systems.
- Monitoring and review of the implementation of various programmes or activities taken up for prevention, control and abatement of pollution in the river Ganga.
- Issue directions under section 5 of the Environment (Protection) Act, 1986 for the purpose of exercising and performing these functions and for achievement of its objectives.

Ans 7. Effluent quality of textile industry

The textile dyeing industry consumes large quantities of water and produces large volumes of wastewater from different steps in the dyeing and finishing processes. Wastewater from printing and dyeing units is often rich in color, containing residues of reactive dyes and chemicals, and requires proper treatment before being released into the environment.

Cotton provides an ecologically friendly textile, but more than 50% of its production volume is dyed with reactive dyes. Unfortunately, dyes are unfavorable from an ecological point of view, because the effluents generated are heavily colored, contain high concentrations of salts, and exhibit high biological oxygen demand/chemical oxygen demand (BOD/COD) values. The textile industry comprises a diverse and fragmented group of establishments that produce and/or process textile-related products (fiber, yarn, and fabric) for further processing into apparel, home furnishings, and industrial goods. Textile establishments receive and prepare fibers; transform fibers into yarn, thread, or webbing; convert the yarn into fabric or related products; and dye and finish these materials at various stages of production. Textiles generally go through three or four stages of production that may include yarn formation, fabric formation, wet processing, and textile fabrication.

The processes and their associated releases of waste water components are shown below

Process	Wastewater
Fiber preparation	Little or no wastewater generated
Yarn spinning	Little or no wastewater generated
Slashing/sizing	BOD; COD; metals; cleaning waste, size
Weaving	Little or no wastewater generated
Knitting	Little or no wastewater generated
Desizing	BOD from water-soluble sizes; synthetic size; lubricants; biocides; anti-static compound
Scouring	Disinfectants and insecticide residues; NaOH; detergents; fats; oils; pectin; wax; knitting lubricants; spin finishes; spent solvents
Bleaching	Hydrogen peroxide, sodium silicate or organic stabilizer; high pH
Mercerizing	High pH; NaOH
Dyeing	Metals; salt; surfactants; toxics; organic processing assistance; cationic materials; color; BOD; sulfide; acidity/ alkalinity; spent solvents.
Printing	Suspended solids; urea; solvents; color; metals; heat; BOD; foam.
Finishing	BOD; COD; suspended solids; toxics; spent solvents
Product fabrication	Little or no wastewater generated.

Ans. question 8. Advanced methods of domestic waste water treatment

General overview of domestic waste water treatment

Sewage treatment generally involves three stages, called primary, secondary and tertiary treatment.

(1)Primary treatment consists of temporarily holding the sewage in a quiescent basin where heavy solids can settle to the bottom while oil, grease and lighter solids float to the surface. The settled and floating materials are removed and the remaining liquid may be discharged or subjected to secondary treatment.

(2) Secondary treatment removes dissolved and suspended biological matter. Secondary treatment is typically performed by indigenous, water-borne micro-organisms in a managed habitat. Secondary treatment may require a separation process to remove the micro-organisms from the treated water prior to discharge or tertiary treatment.

(3) Tertiary treatment is sometimes defined as anything more than primary and secondary treatment in order to allow rejection into a highly sensitive or fragile ecosystem (estuaries, low-flow Rivers, coral reefs). Treated water is disinfected chemically or physically (for example, by lagoons and microfiltration) prior to discharge into a stream, river, bay, lagoon or wetland, or it can be used for the irrigation of a golf course, green way or park. If it is sufficiently clean, it can also be used for groundwater recharge or agricultural purposes

In addition to the conventional sewage treatment methods, there are some advanced methods which are highlighted below in detail:

[1] Constructed wetlands

Constructed wetlands (can either be surface flow or subsurface flow, horizontal or vertical flow), include engineered reedbeds and belong to the family of phytorestoration and ecotechnologies; they provide a high degree of biological improvement and depending on design, act as a primary, secondary and sometimes tertiary treatment.

[2] Soil bio-technology

A new process called soil bio-technology (SBT) developed at IIT Bombay has shown tremendous improvements in process efficiency enabling total water reuse, due to extremely low operating power requirements of less than 50 joules per kg of treated water. Typically SBT systems can achieve chemical oxygen demand (COD) levels less than 10 mg/L from sewage input of COD 400 mg/L

[3] Biological aerated filters

Biological Aerated (or Anoxic) Filter (BAF) or Biofilters combine filtration with biological carbon reduction, nitrification or denitrification. BAF usually includes a reactor filled with a filter media. The media is either in suspension or supported by a gravel layer at the foot of the filter. The dual purpose of this media is to support highly active biomass that is attached to it and to filter suspended solids. Carbon reduction and ammonia conversion occurs in aerobic mode and sometime achieved in a single reactor while nitrate conversion occurs in anoxic mode. BAF is operated either in upflow or downflow configuration depending on design specified by manufacturer.

[4] Rotating biological contactors

Rotating biological contactors (RBCs) are mechanical secondary treatment systems, which are robust and capable of withstanding surges in organic load. RBCs were first installed in Germany in 1960 and have since been developed and refined into a reliable operating unit. The rotating disks support the growth of bacteria and micro-organisms present in the sewage, which break down and stabilize organic pollutants. To be successful, micro-organisms need both oxygen to live and food to grow. Oxygen is obtained from the atmosphere as the disks rotate. As the micro-organisms grow, they build up on the media until they are sloughed off due to shear forces provided by the rotating discs in the sewage. Effluent from the RBC is then passed through final clarifiers where the micro-organisms in suspension settle as a sludge. The sludge is withdrawn from the clarifier for further treatment.

[5] Nitrogen removal

The removal of nitrogen is effected through the biological oxidation of nitrogen from ammonia to nitrate (nitrification), followed by denitrification, the reduction of nitrate to nitrogen gas. Nitrogen gas is released to the atmosphere and thus removed from the water.

[6] Phosphorous removal

Phosphorus can be removed biologically in a process called enhanced biological phosphorus removal. In this process, specific bacteria, called polyphosphate accumulating organisms (PAOs), are selectively enriched and accumulate large quantities of phosphorus within their cells (up to 20 percent of their mass). When the biomass enriched in these bacteria is separated from the treated water, these biosolids have a high fertilizer value.

Phosphorus removal can also be achieved by chemical precipitation, usually with salts of iron (e.g. ferric chloride), aluminum (e.g. alum), or lime. This may lead to excessive sludge production as hydroxides precipitates and the added chemicals can be expensive. Chemical phosphorus removal requires significantly smaller equipment footprint than biological removal, is easier to operate and is often more reliable than biological phosphorus removal. Another method for phosphorus removal is to use granular laterite.