Q1. What is **"Hydrological Cycle"**? Now-a-days there is general discussion that Hydrological Cycle has been disturbed. Is this a myth or reality? Briefly explain.

Answer 1. **"Hydrological Cycle"** is defined as continuous natural process of exchange of water from land and ocean surface to the atmosphere and vice versa by the influence of solar heat or solar radiations. It is also termed as **"Water Cycle"**.

"Hydrological Cycle" is defined as sum of all processes of water movement from the earth's surface (land & ocean) to the atmosphere and back in the form of precipitation.

It deals with the continuous circulation of water in the Earth-atmosphere system i.e origin and distribution of water in the Hydrosphere. The water around the globe exists in all states of matter- solid, liquid and gas.

Basic components of Hydrological Cycle are:

a- Evaporation b- Condensation c- Precipitation d-Infiltration e- Interception f- Percolation g-Transpiration h-Evapo-transpiration i-Runoff j- Depression Storage

According to the water balance equation the total water content of hydrosphere is almost constant but it's proportion as fresh water, ocean, surface water, saline water, ground water, humidity etc. varies with wide range of climatic changes and human factors. Due to industrial & urban development, transportation system using hydrocarbons as source of energy, deforestation, extensive and misuse of agriculture land has given rise to the production of Greenhouse gases. Greenhouse gases trap heat from escaping to the space resulting in global warming. The combined land and ocean temperature has increased at an average rate of 0.07°C (0.13°F) per decade since 1880; however, the average rate of increase since 1981 (0.18°C / 0.32°F) is more than twice as great (Ref. NOAA 2019 Global Climate Summary).

The effects of Global warming and other human factors on the Hydrological Cycle are as follows:

1. Surface temperature increase is greatest in Polar Region resulting in retreat of glaciers, permafrost and sea ice.
2. Rising Sea Levels.
3. Regional changes in precipitation.
4. More frequent extreme weather (Extreme flooding and drought).
5. Expansion of deserts.
6. Overall, higher temperatures bring more rain and snowfall, but for some regions droughts and wildfires increase, instead.

7. Changes in water vapour concentration, clouds, precipitation patterns and stream flow patterns.
8. Acid rain.
9. Water pollution due to use of insecticides & pesticides, discharge of industrial & domestic waste into water bodies.
10. Depletion of groundwater.
11. Water logging and Salinity due to extensive use of irrigation system.

It is not a myth but rather a fact that the Hydrological Cycle has been disturbed. The total water content remains the same but the quality (Chemical Composition) and quantity (Percentage Proportion) of different sources of water have changed drastically.

Q2. Briefly describe "**Ground water Sustainability"**? How can **"Rainwater Harvesting"** be linked to ground water sustainability?

Answer2. **Groundwater sustainability** is the efficient development and utilization of groundwater resources to fulfill the present and future beneficial uses without having adverse environmental or socioeconomic effects.

Groundwater is the most abundant source of fresh water on earth (98%) and crucial to human development. It is the resource hidden in the pores and cracks underground, after percolating from the earth's surface or having been trapped due to sedimentation or volcanic activity. It is stored in and moves slowly through geologic formations of soils, sand and rocks called aquifers.

Groundwater is one of the extremely valuable renewable resources. Now a day's pollution of groundwater resources is a matter of serious concern. Groundwater quality is based upon it's physical, chemical, biological and radiological parameters. Continuous discharge of industrial effluents, domestic sewage, use of fertilizers, insecticides and pesticides, waste dump and extensive exploitation of the resource have badly impacted the groundwater sustainability.

Impact of Groundwater Depletion:

- Lowering of water table
- Increased cost of pumping
- Reduction in surface water supplies
- Land subsidence
- Water quality concerns

- Loss of wetland and riparian vegetation
- Severe crisis of safe drinking water and irrigation water

During monsoon/heavy rain season there is plenty of rain, resulting in surface runoff which enters seas without being used beneficially. **Rainwater Harvesting** is a technique of collection and storage of rainwater into natural reservoirs or tanks, or the infiltration of surface water into subsurface aquifers (before it is lost as surface runoff). **Rainwater harvesting** is the accumulating and storing of rainwater for reuse, in natural or manmade catchment areas. Catchment includes rooftops, compounds, rocky surface or hill slopes or artificially prepared impervious/semi-pervious land surface. Collection of rainwater using various techniques and then storing and using of that water for drinking and agriculture purpose is known as **Rainwater Harvesting.** It is the most effective method for water conservation.

Methods of Rainwater Harvestings:

1. Rooftop Rainwater Harvesting
2. Surface Runoff Rainwater Harvesting

Due to rapid urbanization, infiltration of rainwater into the sub-soil has decreased drastically and recharging of groundwater has diminished. Artificial recharge with rainwater harvesting techniques offers an excellent scope to arrest this degradation. Rainwater harvesting is linked with groundwater sustainability having the following impacts on groundwater.

a. Enhances the water table.
b. Improves the groundwater quality through dilution.
c. Increases the storage capacity and conserve groundwater.
d. Reduce the energy cost of pumping of groundwater.
e. Controls salinity and other chemical composition of water.
f. Stops underground erosion.
g. Serves as an alternate source during emergency.

Q3. What **"Quality Parameters"** should be considered in designing water supply system for a community?

Answer3: Human life is dependent on various factors of which water is of primary importance. Water is required for industrial & domestic use, irrigation and power generation. The selection of the water source for water supply system for a community is based on the following three criteria.
a- Water Quantity b- Water Reliability c- Water Quality

Industrial revolution, urbanization, modern means of transportation and energy development - use of fertilizers, insecticides and pesticides in the agriculture sector-are sources of air and water pollution. In addition to man-made pollution, water sources are also contaminated by natural means having dissolved or suspended harmful components. Major sources of water supply are groundwater and surface water, both of which are exposed to contamination. Therefore, to ensure potable water, it must be tested for the presence of impurities that could be hazardous, having bad smell & colour and nasty taste. If the water source is contaminated it should be treated to remove the impurities. Water Quality is the measure of the condition of water relative to the requirements of one or more biotic species, or to any human need or purpose. Water Quality is the basic criterion in designing water supply system. Water quality is classified into four types
i- Potable Water ii- Palatable Water iii- Contaminated/Polluted Water iv- Infected Water

Design Parameters of Water Quality:
World Health organization has issued guidelines for drinking-water quality. Subsequently every country has established National Environmental Quality Standards. According to Pakistan NEQS following water quality parameters are taken into consideration for designing water supply system for community:
1- Physical 2- Chemical 3- Biological 4- Radiological

1- Physical Parameters:

Characteristics of water that can be determined by the senses of touch, sight, smell and taste are known as physical parameters. Physical indicators are as follows:

a- Water temperature b- Total Dissolved Solids (TDS) c- Total suspended solids (TSS) d- Turbidity e- Electrical conductance f- Odour g- Colour i- Taste

2- Chemical Parameters:

They include the chemical properties of water and are as follows:

a- pH b- Biochemical oxygen demand (BOD) c- Chemical oxygen demand (COD) d- Dissolved oxygen (DO) e- Total Hardness (HD) f- Heavy metals g- Nitrates h- Orthophosphates i- Pesticides h- Surfactants

3- Biological Parameters:

Drinking water should not contain any microorganism known to be pathogenic-capable of causing disease-or any bacteria indicative of faecal pollution. The presence or absence of living organisms in water are the basis of biological parameters which are as follows:

a- Bacteria b- Algae c- Viruses d- Protozoa

4- Radiological Parameters:

Wastes from nuclear power plants, industries, or medical research using radioactive chemicals and mining of uranium ores or other radioactive materials are the potential sources of water contamination.

National Standards for Drinking Water Quality:

Properties/Parameters	Standard Value for Pakistan	WHO Standards
Bacterial		
All water intended for drinking (E.Coli or Thermo tolerant Coliform bacteria)	Must not be detectable in 100 ml sample	Must not be detectable in 100 ml sample
Treated water entering any distribution system (E.coli or Thermo tolerant Coliform & total Coliform bacteria)	Must not be detectable in 100 ml sample	Must not be detectable in 100 ml sample
Treated water entering any distribution system (E.coli or Thermo tolerant Coliform & total Coliform bacteria)	Must not be detectable in 100 ml sample In case of large supplies where sufficient samples are examined, must not be present in 95% of the samples taken throughout any 12-month period.	Must not be detectable in 100 ml sample In case of large supplies where sufficient samples are examined, must not be present in 95% of the samples taken throughout any 12-month period.
Physical		
Colour	</= 15 NTU	</= 15 NTU
Taste	Non Objectionable/Acceptable	Non Objectionable/Acceptable
Odour	Non Objectionable/Acceptable	Non Objectionable/Acceptable
Turbidity	< 5 NTU	< 5 NTU
Total hardness as $CaCo_3$	< 500 mg/l	---------
TDS	< 1000	< 1000
pH	6.5-8.5	6.5-8.5
Chemical		
Essential Inorganic	mg/litre	mg/litre
Aluminum (Al)	</= 0.2	</=0 .2
Antimony (Sb)	</=0.005 (P)	0.02
Arsenic (As)	</=0.05 (P)	0.01
Barium (Ba)	0.7	0.7
Boron (B)	0.3	0.3
Cadmium (Cd)	0.01	0.003
Chloride (Cl)	< 250	250
Chromium (Cr)	</=0.05	0.05
Copper (Cu)	2	2
Toxic Inorganic	mg/litre	mg/litre
Cyanide (CN)	</=0.05	0.07
Fluoride (F)	</= 1.5	1.5
Lead (Pb)	</= 0.05	0.01
Manganese (Mn)	</= 0.5	0.5
Mercury (Hg)	</= o.001	0.001

Properties/Parameters	Standard Value for Pakistan	WHO Standards
Nickel (Ni)	</= 0.02	0.02
Nitrate (NO_3)	</= 50	50
Selenium (Se)	0.01 (P)	0.01
Residual Chlorine	At consumer end 0.2-0.5 At source 0.5-1.5	------
Zinc (Zn)	5.0	3
Organic		
Pesticides mg/L		PSQCA No. 4639-2004 Page No.4 Table No.3 Serial No. 20-58 may be considered
Phelonic compounds as (Phenols) mg/L		</= 0.02
Polynuclear aromatic hydrocarbons as (PAH) g/L		0.01 (ByGC/MS method)
Radioactive		
Alpha emitters bq/L or pCi	0.1	0.1
Beta Emitters	1	1

S0urce: The Gazette of Pakistan dated November 26, 2010.