Muhammad Hussain, Registration ID: 15513, Discipline: MS Civil Engineering, Course Title: Water Demand Supply & Distribution, Course Code: CE-562, Instructor: Nadeem Ullah, Date: 14.04.2020

Q.1.Ans:

HYDROLOGICAL CYCLE:

Hydrological cycle, also known as **water cycle** is defined as the sum of all the processes involved, wherein the water moves from the land and ocean to the atmosphere and back in the form of precipitation.

The process involves the physical processes of evaporation, condensation, precipitation, infiltration, surface runoff and sub-surface flow and hence the water goes through different stages i.e. liquid, solid and vapor.

As far as the discussions regarding the disturbance of Hydrological Cycle is considered, in my opinion, it is a scientific truth rather than a myth. My opinion is based on the following justifications:

As we know that the hydrological cycle is mainly powered or energized by solar energy and about 86% of the global evaporation is obtained from oceans thereby reducing its temperature. Without cooling, the effect of evaporation on the greenhouse effect would lead to a much higher surface temperature of 67 Degree Centigrade and thus leads to a warmer planet. Every one of us is aware of **Green House Gases** and **Global Warming**, let us elaborate it further i.e. the CO2 and other greenhouse gases behave like a blanket, absorbing the Infrared Radiations and thus preventing it from escaping into the outer space and thereby gradually increases the temperature of Earth's atmosphere and surface. This process is known as **Global Warming**. The greenhouse effect is natural process, when the solar energy reaches the earth's atmosphere, some of it is reflected back to space and the remaining absorbed by greenhouse gases. The total water content remains the same but the quality and quantity of different sources of water have changed drastically.

Besides this, number of human activities can also impact the water cycle that includes the storage of water in Dams for producing electricity, deforestation and use of water for farming and mostly the burning of fossil fuels.

As per the information from **IPCC** (Inter Governmental Panel of Climate Change) of UN, that the water cycle will continue to intensify throughout 21^{st} Century and shall have the environmental impact in different regions thereby decreasing the precipitation in areas that are relatively dry and will result in drought. On the other hand, areas that are near the equator and are relatively wet shall have larger precipitations. Also the salty areas will become more saline and the fresher areas becoming fresher over. The effect of the global warming may change the temperature from 2 to 3–degrees warmer and also rises the sea levels. There is now enough evidence that increased hydrologic variability and change in climate will continue to have a greater impact on the water sector through the hydrologic cycle, water availability, and water demand and water allocation at the global, regional and local levels.

Finally, considering the above scientific facts and research, the whole world should look for different solutions to reduce the global warming and adopt practices such as, planting trees, change light, recycle more, turn off electronic devices, check your tires, adjust you thermostat, use less hot water, avoid products with a lot of packing, planning and management of water supply, waste water and storm water in efficient way to reduce GLOBAL WARMING and maintain the Hydrological balance.

Q.2.Ans.

Groundwater Sustainability:

It is defined as the development and the use of groundwater to meet the current as well as future advantageous purposes without creating unacceptable consequences. Ground water is one of the extremely valuable sustainable resource which doesn't recycle rapidly, which is the water that seeps through the soil and accumulates above the non-porous rocks deep underground.

The Groundwater can be used for domestic, industrial and irrigation purposes. Their reserves underground are called aquifers. From studies, it was found out that approximately out of total 37 million cubic kilometers of fresh water, 08 million cubic kilometer is stored as ground water. Groundwater provides almost 50% of all drinking water worldwide and 43% of all consumptive use of water for irrigation in agriculture. Changes in groundwater availability and quality impact human health, livelihoods, food security and national economic development. Many aquatic ecosystems and their biodiversity depend on groundwater. Failure to manage groundwater sustainably puts at risk massive benefits for human well-being, sustainable development and biodiversity conservation. Key technical interventions for groundwater management include control of groundwater pumping to sustainable levels, control of discharges to groundwater and in some areas managing aquifer recharge.

As a hidden resource, the importance of groundwater in social and economic development is easily overlooked. Its value in the economy and economic development is frequently under-estimated when policymakers in governments, business investors or local farmers and communities assume that the springs, wells, and boreholes on which they rely on, will continue to supply high-quality freshwater, forever. Where these mistaken assumptions continue, the benefits of groundwater for development will be lost. Where groundwater management is sustainable, its potential contributions cross multiple dimensions of sustainable development. Sustainable groundwater management can ensure climate-friendly supplies of water needed to help meet goals for food security, energy development and access to drinking water. It can supply water for sustainable cities and industrialization.

Rainwater Harvesting technique can be efficiently linked to the Groundwater sustainability in the following manner. Let us first elaborate the Rainwater Harvesting and then see how it can be linked to improve the quantity and quality of **groundwater**.

Rainwater harvesting is defined as a process in which the raindrops are collected and kept for future use rather than letting it to run off. It is mainly of two types, namely rooftop and surface runoff harvesting. Once collected can be redirected to well, boreholes, reservoir or aquifer by adopting appropriate methods. It can be used for gardening, live stokes, irrigation and domestic use. **Rainwater harvesting** is a multipurpose way of supplying usable water to consumers during a crisis period, recharging the groundwater and finally reducing the runoff and water logging during the season of heavy rainfall. Traditional knowledge, skills, and materials can be used for this system.

Rainwater harvesting also provides independent water supply during the period of regional water restrictions and is often supplemented as main water supply in the developed countries. During the drought, it provides the water and can help in the mitigation of floods in low lying areas. It also reduces the demand on wells and thus **sustains the groundwater levels**.

Adoption of rooftop rainwater harvesting followed by its storage through artificial recharge methods at household level could be a viable strategy to locally tackle the growing water scarcity problem that is prevalent in most of the towns and cities of the World. Artificial groundwater recharge methods can be adopted in urban areas by the utilization of **Rainwater Harvesting** where groundwater level occurs at a depth of 5m or more Permeable strata is available at shallow or moderate depth. Groundwater quality needs improvement, there are possibilities of saline water intrusion in coastal areas and evaporation rate from surface storage will be very high. The Artificial Recharge techniques are more suitable for large-scale **Rain Water Harvesting projects** with huge catchment area. They may also be appropriate for institutional campuses with Iarge rooftop as well as open surface area. Many simple and low-cost artificial techniques have been developed and practiced to encourage households to adopt **RWH** practice.

Rainwater harvesting (RWH) for groundwater recharge is seen as one of the solutions to solve the groundwater problem. This is reflected in an increase in watershed development programs, in which **RWH** is an important structural component. Understanding the net effect of these development programs is crucial to ensure that net effect on groundwater is positive both locally and within a watershed. The appropriate design and evaluation of a **RWH** system is necessary to improve system performance and the stability of the water supply.

Q.3.Ans.

Water is the second most important need for life to exist after air. As a result, water quality has been described extensively in the scientific literature. The most popular definition of water quality is “it is the physical, chemical, and biological characteristics of water”. Water quality is a measure of the condition of water relative to the requirements of one or more biotic species and/or to any human need or purpose.

Classification of water:

Based on its source, water can be divided into ground water and surface water. Both types of water can be exposed to contamination risks from agricultural, industrial, and domestic activities, which may include many types of pollutants such as heavy metals, pesticides, fertilizers, hazardous chemicals, and oils.

Water quality can be classified into four types—potable water, palatable water, contaminated (polluted) water, and infected water. The most common scientific definitions of these types of water quality are as follows:

1. **Potable water**: It is safe to drink, pleasant to taste, and usable for domestic purposes.
2. **Palatable water**: It is esthetically pleasing; it considers the presence of chemicals that do not cause a threat to human health.
3. **Contaminated (polluted) water**: It is that water containing unwanted physical, chemical, biological, or radiological substances, and it is unfit for drinking or domestic use.
4. **Infected water**: It is contaminated with pathogenic organism.

Parameters of water quality:

There are three types of water quality parameters **physical, chemical, and biological**. They are briefly described as follows:

Physical:

1. Turbidity
2. Temperature
3. Color
4. Taste & Odor
5. Solids
6. Electrical Conductivity (EC)

Chemical:

1. PH
2. Acidity
3. Alkalinity
4. Chloride
5. Chlorine Residual
6. Sulphate
7. Fluoride
8. Nitrogen
9. Iron & Magnesium
10. Copper & Zinc
11. Hardness
12. Dissolved Oxygen
13. Bio-Chemical Oxygen Demand (BOD)
14. Chemical Oxygen Demand (COD)
15. Toxic Organic Substances
16. Radioactive Substances

Biological:

1. Bacteria
2. Algae
3. Viruses
4. Protozoa
5. Indicator Organisms.

Water quality requirements should be agreed with the water quality standards, which are put down by the governmental agency and represent the legislation requirements. In general, there are three types of standards: in-stream, potable water, and wastewater effluent, each type has its own criteria by using the same methods of measurement. The World Health Organization (WHO) has established minimum standards for drinking water that all countries are recommended to meet. They summarized as follows:

NATIONAL STANDARDS FOR DRINKING WATER QUALITY			
Properties/Parameters	**Standard Values for Pakistan**	**WHO Standards**	**Remarks**
BACTERIAL:			
All Water intended for drinking (E-Coli or Thermotolerant Coliform Bacteria)	Must not be detectable in any 100 ml sample	Must not be detectable in any 100 ml sample	Most Asian Countries follow WHO standards
Treated Water Entering the Water distribution system (E-Coli or Thermotolerant Coliform and Total coliform Bacteria)	Must not be detectable in any 100 ml sample	Must not be detectable in any 100 ml sample	Most Asian Countries follow WHO standards
Treated Water in the distribution system (E-Coli or Thermotolerant Coliform and Total coliform Bacteria)	Must not be detectable in any 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 any 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.	Most Asian Countries follow WHO standards
PHYSICAL:			
Color	≤ 15 TCU	≤ 15 TCU	
Taste	Non Objectionable/Acceptable	Non Objectionable/Acceptable	
Odor	Non Objectionable/Acceptable	Non Objectionable/Acceptable	
Turbidity	5 NTU	5 NTU	

Total Hardness as COC3	<500 mg/l		
TDS	1000	1000	
PH	6.5 - 8.5	6.5 – 8.5	
CHEMICAL:			
Essential Inorganic	mg/liter	mg/liter	
Aluminum (Al)	≤0.02	0.2	
Antimony (Sb)	≤0.005 (P)	0.02	**Standard for Pakistan similar to most developing Countries**
Arsenic (As)	≤0.05P	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/liter	mg/liter	
Cyanide (CN)	≤0.05	0.07	
Fluoride (F)	≤1.5	1.5	
Lead (Pb)	≤0.05	0.01	
Magnese (Mn)	≤0.5	0.5	
Mercury (Hg)	≤0.001	0.001	
Nickle (Ni)	≤0.02	0.02	
Nitrate (NO3)	≤50	50	
Nitrite (NO2)	≤3(P)	3	
Selenium (Se)	0.01P	0.01	
Residual Chlorine	0.2-0.5 at consumer end 0.5- 1.5 at source		
Zinc (Zn)	5.0	3	
ORGANIC			
Pesticides (mg/L)		PSQCA No. 4639-2004.	
Phenolic Compounds (as Phenols) mg/L		≤ 0.002	
Polynuclear aromatic hydrocarbons (as PAH) g/L		0.01 (By GC/MS method)	
RADIOACTIVE			
Alpha emitters bq/L or pCi	0.1	0.1	
Beta emitters	1	1	

Conclusion:

The physical, chemical, and biological parameters of water quality are reviewed in terms of definition, sources, impacts, effects, and measuring methods. The classification of water according to its quality is also covered with a specific definition for each type.