Int.J.Curr.Res.Aca.Rev.2022; 10(08): 33-42

EXCELLENT PUBLISHERS

International Journal of Current Research and Academic Review

ISSN: 2347-3215 (Online) Volume 10 Number 08 (August-2022)

Journal homepage: http://www.ijcrar.com

doi: https://doi.org/10.20546/ijcrar.2022.1008.003

Ground Water Depletion: Causes, Effect and Practices to Conquer

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Abstract

In every part of the world, groundwater is an extremely valuable resource. Groundwater provides many of the hydrologic needs of people around the world where surface water is sparse or inaccessible. More than 1.1 billion people around the world do not have access to water, and another 2.7 billion do so for at least a month out of the year. Cropping intensity might be reduced by up to 20% and up to 68% in areas with low future groundwater availability in India by 2025. Long-term water level drops produced by persistent groundwater pumping are a common definition of the phrase "groundwater depletion." Groundwater is becoming depleted in many parts of the world. Concerningly, India is one of the world's leading agricultural producers, and more than 600 million Indian farmers rely on agriculture for their livelihood. This article will aid comprehension of the fundamental causes of groundwater depletion and the strategies to combat water scarcity.

Article Info

Received: 06 July 2022
Accepted: 28 July 2022
Available Online: 20 August 2022

Keywords

Freshwater, Blue Planet, airborne vapour, soil wetness, lakes, rivers, and swamps.

Introduction

Water makes up over 71 percent of the Earth's surface in the form of oceans, seas, rivers, and other water bodies, earning Earth the nickname "Blue Planet" (Nellemann, and Corcoran, 2009) Approximately 96.5 percent of the world's salty water is contained in the oceans.

Only 3 percent of the water on the surface is freshwater; the remaining 69 percent is in the form of glaciers, 30 percent is found underground, and less than 1 percent is found in lakes, rivers, and swamps. Aquifers, soil wetness, and airborne vapour are some places where water can be found (Miola *et al.*, 2006).

Among all available sources of fresh water, groundwater is essential to global economic development, water availability, and food security (Falkenmark, 2001). Despite the creation of irrigation plans based on surface water, groundwater continues to be the principal source of irrigation in a huge portion of the nation. Through the development of groundwater-based irrigation, the Green revolution of the 1970s significantly increased food production in India (Paddock, 1970).

As a result, the irrigation area is increased, and the quantity of electric and diesel pumps is rapidly increasing. Growing numerous harvests in a year with higher crop yields was made possible because to the conversion of a sizable portion of the rain-fed terrain to irrigated agriculture. Increased groundwater-based irrigation helped India's population fulfil its rising food demand, but it also had a number of negative environmental effects (Zaveri *et al.*, 2016).

One of the biggest threats to food and water security in India today is groundwater depletion. Groundwater storage in north India is rapidly declining, according to in-situ and satellite-based measurements. In India, groundwater depletion is a result of both natural and human-made forces (Barlow and Clarke, 2017). Groundwater pumping for irrigation continues to be the main cause of groundwater depletion, which can worsen under the effects of climate change in India and threaten food and water security. There are problems and uncertainties with both in-situ and satellite-based measurements. The depiction of complex processes connected to climate-human interactions has to be improved in land surface hydrological models, despite the fact that they offer crucial insights into the variability of groundwater storage. For India to address the escalating problems with water supply, sustainable groundwater management is essential (Shankar *et al.*, 2011).

Water Table

The water table is an underground line separating the soil's surface from the region where groundwater seeps into rock crevices and voids between sediments (Ashley *et al.*, 2013). At this limit, the water pressure and atmospheric pressure are equal. A water table, according to National Geographic, is the line separating earth that has been saturated with water from unsoaked ground. Aquifers are pockets of water that exist deep underground, at different depths based on topography, geology, and weather. The dry surface and that available water are separated by the water table (Mandel, 2012).

Precipitation, irrigation, and ground cover all have an effect on ground water. Land usage and tides may also have an impact. According to Encyclopedia Britannica, the water table can change with the seasons and from year to year since it is impacted by climatic changes as well as how much water can be extracted from the earth. Where one individual lives, the water table may be several inches or even many feet below the surface of the ground, and it will generally follow the contour of the terrain. Others may have it much higher, even rising over the soil's surface (Kendy *et al.*, 2004).

The water table as well as local soil conditions and drainage can impact homes and their foundations. It might not be a concern if the soil drains well and the water table is reasonably low (Cedergren, 1997). However, the earth around a residence may swell and get saturated if the soil is deep and absorbent and the water table is high. According to Rytech, a water damage and mould restoration firm, this can put a lot of pressure on the foundation walls. Water can exert "hydrostatic pressure" on the underside of a foundation in regions where the local water table rises close to the surface. As a result, water may eventually seep through the foundation's bottom and even through solid concrete. In extreme cases of hydrostatic pressure, the foundation might be partially lifted out of the earth, but this is extremely improbable. However, it might result in the shifting of structures like fences, decks, and foundation walls (Prud'Homme, 1995).

Scenario

In many parts of the country and the world, groundwater decline is a real and significant issue. The flow of streams and rivers decreases, water levels in lakes and reservoirs drop, and the depth of water in wells rises when rainfall is below average for numerous weeks, months, or years (Muir-Wood and King, 1993). More than a quarter of the world's population and a third of those living in emerging nations now reside in areas that will have severe water shortages by the turn of the century. An worrying amount of groundwater is being lost. Professionals and decision-makers must urgently focus their attention on the issues of ground water depletion, which must be viewed as the greatest danger to food security in the twenty-first century (Llamas and Martínez-Santos, 2005).

Water has been a bountiful resource and essentially a free good for thousands of years of human history. However, this is suddenly changing, especially in the drier parts of the world, where water shortage is now the biggest danger to food security, human health, and natural ecosystems. According to a recent study by the International Water Management Institute (IWMI) (Seckler *et al.*, 1998), we calculated that close to 1.4 billion people roughly one-fourth of the world's population or one-third of the population in developing nations live in areas that will face severe water scarcity during the remaining quarter of the twenty-first century. By 2025, there will be an utter water shortage for the little more than one billion people who live in arid regions. Even at high irrigation efficiency levels, these regions do not have enough water resources to meet reasonable water needs for domestic, industrial, and environmental uses by 2025 (Seckler, 2003). They also do not have enough water resources to maintain 1990 levels of per capita food production from irrigated agriculture. As a result, people in these areas will have to use less water for agriculture and divert it to other uses, decreasing local food output and increasing food imports. Severe economic water scarcity affects an additional 348 million people. They reside in areas where the potential water resources are adequate to supply tolerable water needs by 2025, but they will need to launch huge water development projects to accomplish this goal, which will be extremely expensive and may cause serious environmental harm (Armaroli and Balzani, 2007).

Ground water

Precipitation is the source of groundwater. To get to the zone of saturation, where groundwater movement takes place, precipitated water must pass through the vadose zone. The kind of soil, rock, water present previously, and time all influence the rate of infiltration (Ortegón, 2016).

Between the surface of the Earth and the zone of saturation is the vadose zone. The water table is located close to the top of the zone of saturation, where water pressure equals air pressure. The water table is directly covered by a layer of varying thickness known as the capillary fringe. Capillary action causes water to be pulled into this layer (Gillham, 1984). In groundwater systems, the vadose zone plays a significant environmental role. Surface contaminants, like water, must pass through the vadose zone to reach the saturation zone.

Aquifers

Aquifers are underground reservoirs that hold large volumes of water. The water that is stored must be readily accessible in order for there to be an aquifer. Sand, gravel, and rock that has been split make up aquifers. Both confined and unconfined aquifers exist. Non-porous layers are present both above and below the aquifer zone in confined aquifers. Water is trapped in the non-porous layers, which also impede water flow. Aquitards or aquicludes are the names for these layers. Aquitards include non-fractured, weakly porous igneous and metamorphic rocks, clay soils, and shales. There may occasionally be a non-porous lens in a more permeable substance (National Academies of Sciences, Engineering, and Medicine, 2020). This layer will stop any water that is trying to percolate through the unsaturated zone, causing it to collect on top of the lens. A perched aquifer supplies this water. The confining layers that slow water flow do not exist in an unconfined aquifer. Under pressure, some aquifers are constrained. The term "artesian systems" refers to these aquifers. The term "artesian systems" refers to these aquifers. Water that flows freely either from a spring or a well is the result of sufficient pressure (Bryan, 1919).

Through aquifer systems, water is continuously recycled. Any additional water to the aquifer zone is known as groundwater recharge. Precipitation, streamflow, leakage (from reservoirs, lakes, and aqueducts), and artificial methods are all factors in groundwater recharge (injection wells; Scanlon *et al.*, 2007). Any procedure that drains water from an aquifer system is referred to as groundwater discharge. Examples of discharge procedures include man-made wells and natural springs. A cone of depression forms in the water table at the well site as a result of pumping water from a well. There are two outcomes from over pumping. The direction of groundwater flow may shift as a result. Additionally, it lowers the water table, necessitating the construction of a deeper well (Loheide and Gorelick, 2007).

Groundwater Movement

Groundwater movement is influenced by the characteristics of the rock and sediment as well as the possibility for flow. Important characteristics of groundwater flow include porosity, permeability, specific yield, and specific retention. The ratio of pore space volume to the total volume (rock and/or sediment plus pore space) is known as porosity. The initial intergranular void space present (primary porosity, expressed as a percentage of pore space) during rock formation. Later development results in secondary porosity (percent additional openings). It is the end result of dissolution, faulting, or fracturing. Porosity is also impacted by cementation and grain form (Purser *et al.*, 1994).

The ability of a rock to let the flow of fluids is referred to as permeability. The size of the pore spaces and the degree of interconnectivity of the pore spaces determine the permeability. Permeability is impacted by grain packing, shape, and cementation. The volume of water that drained from a rock as a result of gravity to the total volume of the rock is measured as the specific yield (Sy). Specific yield is definitely impacted by grain size. Larger surface areas are seen in smaller grains. Greater surface tension results from larger surface areas. The specific yield of fine-grained sediment will be smaller than that of more coarse-grained sediment. Groundwater circulation is impacted by material sorting. Material that has been improperly sorted is less permeable (Tulaczyk, 1999).

Need of Water

At the moment, irrigation accounts for approximately 90% of all water used worldwide, and more than 40% of crops are grown in irrigation systems. Therefore, it is vital to model irrigation water requirements in order to evaluate the future water and food situation. Even regions that do not currently experience water scarcity issues will be constrained in their ability to develop agriculturally and, as a result, may experience food insecurity due to a lack of water availability, as it is very likely that water demands for the domestic and industrial sectors will rise in the future (Döll and Siebert, 2002).

Crop Water Requirement

The term "water need" for crops refers to the volume of water that must be irrigated onto the crop to ensure optimal crop growth. Water is an integral part for sustaining a life and its Importance may be realized from daily life uses of water, which may include activities like drinking, bathing, cooking, cleaning dishes, washing clothes, watering plants, Cleaning fruits, cleaning vegetables, Brushing teeth, generation of hydroelectric power etc (Gleick, 1998).

Both direct and indirect uses of water are possible. While bathing, drinking, and cooking are examples of direct uses of water, indirect uses include the production of steel for automobiles and the processing of wood to manufacture paper. Agriculture, industry, and energy utilise the majority of the water in the globe (Mekhilef *et al.*, 2011).

Domestic uses of water

Domestic water use includes indoor and outdoor uses at residences, and includes uses such as drinking, food preparation, bathing, washing clothes and dishes, flushing toilets, watering lawns and gardens, and maintaining pools (Yari and Eslamian, 2020).

Agricultural use of water

Agriculture is the largest consumer of water. About 70% of water is used for irrigation. Water is necessary for gardening, farming and fisheries. Plants require water to grow. During the process of photosynthesis, they consume water. To yield crops, fruits, flowers, vegetables they need sufficient water, manure, sunlight and oxygen (Bhattarai *et al.*, 2004).

Industrial uses of water

It is either used in creating or to cool the equipment used for creating the product. Industrial water is used for washing, cooling, processing, transporting, diluting or fabricating of a product. The maximum amount of water is used in the production of chemical, paper and food. Other uses are – it is used in transportation, manufacturing, hydroelectric power, removal of body wastes, tourism and recreation (Davies and Cahill, 2000).

Chief cause for water table depletion

Simply put, it is related to how much water is dragged from the earth; when more water is removed from the surface than seeps into the soil, the water table is drained. Rainwater seepage replenishes the water that is taken out of the ground. As long as we only extract as much water as is replenished naturally, the water table is unaffected. If the water is not sufficiently replenished, the water table could decrease. There are numerous potential causes for this (Jaynes and Isenhart, 2014).

Increased Frequency of Pumping Water from the Ground

When we pump water more quickly than it can replenish itself, the water table is drained. With a growing population, it becomes more and more challenging for the groundwater to replenish itself and supply us with the quantity of water we require (Healy and Cook, 2002).

Decreased Recharging Time

The saturated rocks known as aquifers allow water to freely and slowly flow through them. Aquifers of various sizes serve as subsurface water reservoirs. Aquifers can store billions of gallons of water, which they can release to us every day. These aquifers are sucked out, though, before they are refilled. As a result, it is unable to swiftly gather enough water to be a reliable source for our needs (Alley *et al.*, 1999).

Increase in population

Population growth generates demand for the building of homes, businesses, offices, roads, and pavements. As a result, there are less open spaces like playgrounds and parks. In turn, this lessens the amount of rainwater that seeps into the earth. We are allowing less groundwater to leak into the ground because we are using more groundwater for the aforementioned projects. Water gets depleted as a result of this (Araghieyan and Gastineau Romero, 2021).

Industrial activities

The industrial sector uses water in numerous ways, including for cleaning, heating and cooling, creating steam, as a solvent and for conveying dissolved compounds, and as a component of the industrial product itself.

Typically, the amount of water withdrawn for industrial use exceeds the amount actually utilised. Direct disposal untreated into the ground, or via streams, rivers, and canals to aquifers, disposal to municipal sewer systems, which may or may not include sewage treatment, and treatment of wastewater on-site prior to disposal are the primary factors that diminish the suitability of water for human and agricultural use (Downey and Van Willigen, 2005).

Agricultural activities

In India, the vast majority of farmers rely on rain to irrigate their crops. There are only a few sites with irrigation systems like canals. Farmers must therefore use groundwater for irrigation. Groundwater use is rising day by day as a result of population strain on agriculture.

It is unsettling to realize that there isn't much groundwater left to support our individual lifestyles and water needs while the population grows at an alarming rate (Alley and Alley, 2017). The demand for agriculture increases as the number of mouths to feed rises.

Groundwater is increasingly necessary for agricultural techniques as agricultural demands soar. Groundwater availability steadily decreases as a result of aquifers that cannot replenish themselves (Alley *et al.*, 1999).

Irregular Monsoon Patterns

Rainfall is the main factor affecting the water table. Rainwater recharges aquifers by permeating the soil. The condition of the water table depletion has been made worse by poor monsoon trends. Farmers are forced to dig deeper for groundwater because of insufficient rainfall, which further lowers the tables (Sumon and Abul Kalam, 2014).

Deforestation

Trees are cut down to remove forest cover in order to meet the demands of industrialization and urbanization. Rain is made possible by trees. Because there are fewer forests, there is less evapotranspiration and hence less rainfall. Less rainfall prevents water from penetrating the earth and recharges aquifers. There is a lack of groundwater as a result of the deeper water table (Zhang *et al.*, 2001).

Effects of Water table Depletion

The effects of the water table depletion are explained below:

Pumping Water from Deep

Depletion of the water table will force us underground. Deeper excavations beneath the Earth's surface are required as we remove more groundwater. Less water is accessible as we go more below the Earth's surface. The result is a complete drying out of the water table (Dawson *et al.*, 2020).

Wildlife and Vegetation

A lack of groundwater prevents more water from entering lakes, rivers, and oceans. As surface water continues to evaporate, less water will eventually seep into the earth. Everything in that area, including fish and wildlife, is impacted when the water table rises and the seepage of water decreases (Winter, 1999).

Saltwater Contamination

Deep down groundwater frequently mixes with salt water, which is unfit for human consumption. Saltwater contamination is the process through which freshwater and saltwater mingle. Because it will cost more to pump and filter contaminated water, this contamination will result in higher drinking water supply prices (Abd-Elaty *et al.*, 2022).

Scarcity of drinking water

It will be difficult to supply drinking water, water for crops, and water for cattle if there is no water table. We would experience a condition of high demand and low supply as there would be less water available and hence less food to satisfy each mouth (Boretti, and Rosa, 2019).

Fig.1

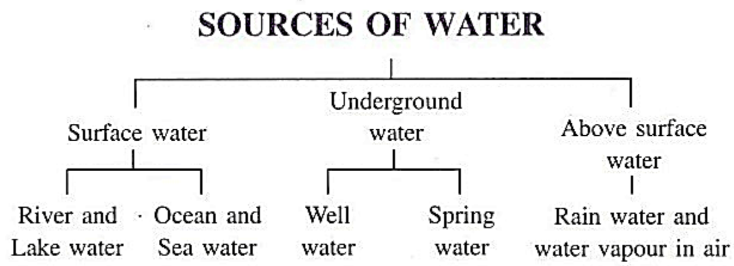


Fig.2

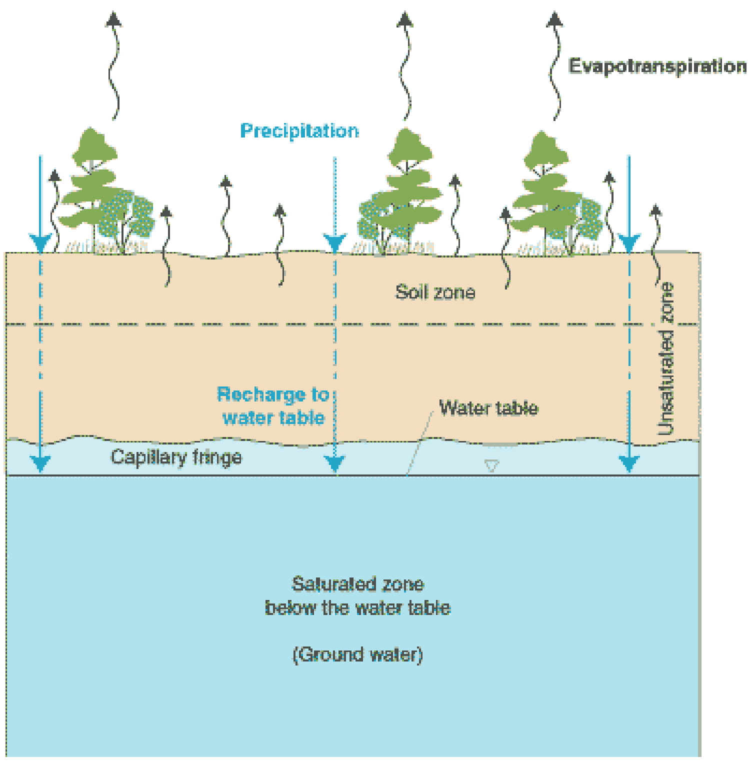


Fig.3

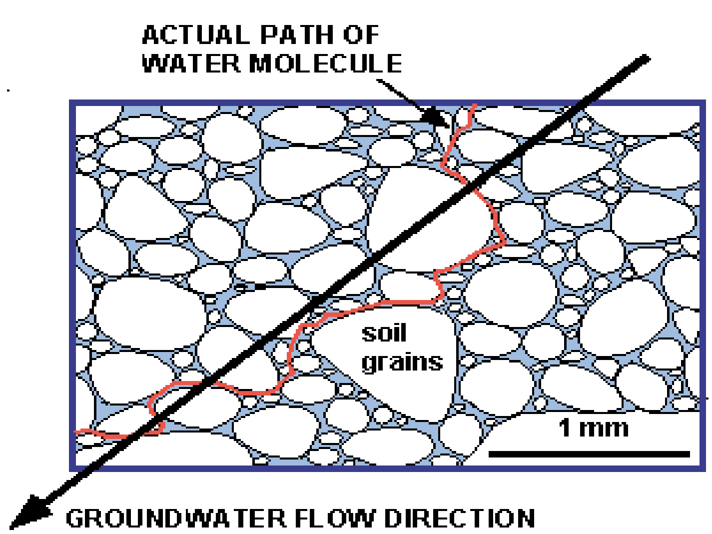
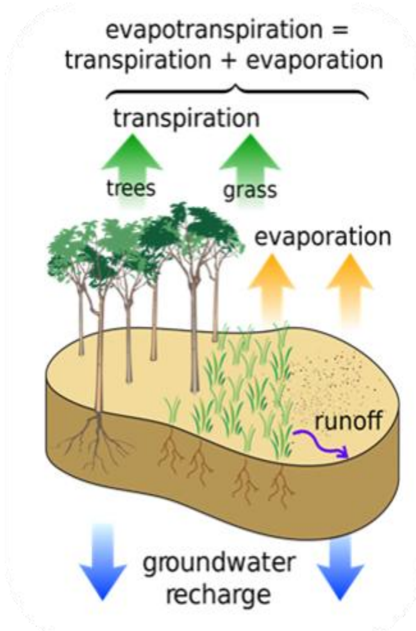


Fig.4



Finished Aquifers

Deadly sinkholes are caused by depleted aquifers, while biodiversity is hampered by a lack of groundwater. Because they collect groundwater, aquifers are very important. Sinkholes develop as the water table recedes, causing damage to buildings and homes as well as to animals, marine life, and agriculture (Urich, 2002).

Solutions to overcome water table depletion

Judicious water consumption

We can all do our part to use less water wherever we can, especially in light of the coming water scarcity issue. Water pipes are kept running in innumerable neighbourhoods for various purposes, including car washing. By using fewer washing machines, dishwashers, and other comparable equipment, we can conserve water (Jury and Vaux Jr, 2007).

Rainwater

Because it typically lacks any impurities, rainwater is the cleanest type of natural water. However, as the first shower descends to earth, it gathers airborne bacteria, pathogens, and dust particles. They therefore have the majority of contaminants (Mohan *et al.*, 2019).

Surface Water

Surface water is present on the surface of the earth. It is of the following types:

River and Lake Water

Rain and the melting of snow on the mountains provide the water for rivers and lakes. Rivers are filled with water that comes from mountains. It transports suspended contaminants while dissolving certain soluble salts along the route. It includes hazardous substances that manufacturers dump into rivers as well as sewage from our towns. Additionally, cholera, typhoid, and jaundice-causing bacteria have been found in river water on occasion. These conditions are known as water-borne illnesses (Nordstrom, 2011).

Seawater

Finally, rivers and streams empty into the sea. The sea dissolves the seawater. A significant quantity of table salt is dissolved in seawater. Saline water, which tastes salty, is the same as seawater. It cannot be used for industrial, agricultural, or drinking purposes (Krachler *et al.*, 2015).

Underground Water or Subsoil Water

A portion of the rain that falls on the land percolates through the soil and descends below the surface. This water eventually comes to a standstill and accumulates between some hard, non-porous rocks. Groundwater or underground water is the term for the liquid that exists below the surface of the earth. The term "water table" refers to the depth of the groundwater (Hedberg, 1964).

By excavating wells that are deep enough to reach the water table, groundwater can be pumped out. Groundwater can also be pumped out using hand pumps or tube wells. For domestic, agricultural, and industrial uses, this groundwater is used. Due to tremendous pressure inside, water occasionally rushes up from the ground in certain locations. It's known as spring water. Different soil strata filter the water from springs and wells. Therefore, it doesn't contain any suspended contaminants (Qureshi *et al.*, 2010a).

Reduced use of chemicals and their proper disposal

Maintaining the health of the water both above and below the Earth's surface is equally vital. Private water homes, businesses that discharge waste into the streets, and sewage systems are frequently filled with chemicals. These substances go into larger bodies of water, seep into the soil, and end up poisoning soil and animals. Lessening the use of chemicals and disposing of them appropriately prevents the introduction of harmful substances into our water supply (Adewole, 2009).

Use of advanced irrigation techniques

It is important to urge farmers to use micro-irrigation methods like drip irrigation and micro-sprinklers. To encourage efficient water use in agriculture, the government has launched programmes including the DRIP programme, more drops per crop, and Krishi Sinchai Yojana (Dhawan, 2017).

More comprehensive research and public, private collaboration

Finding a solution at both the individual and governmental levels is the best method to cope with water table decline. To control groundwater pumping, strict laws should be developed. To identify more water sources, thorough investigation should be done. These might aid in recharging aquifers. Instead than extracting excessive amounts of water from aquifers at once, using water from other sources would give them time to rehydrate (Qureshi *et al.*, 2010b).

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How to cite this article:

Arshi Anees. 2022. Ground Water Depletion: Causes, Effect and Practices to Conquer. *Int.J.Curr.Res.Aca.Rev.* 10(08), 33-42. doi: https://doi.org/10.20546/ijcrar.2022.1008.003