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Agriculture in relation to soil and environmental pollution, global warming and waste water: An overview

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Abstract
There are ample evidences that global warming is caused by human activity: the release of greenhouse gases from burning fossil fuels, industrial processes and changes in land use. Of the man-made pollutants, carbon dioxide (CO_2) is the principal greenhouse gas, but methane, nitrous oxide and industrial chemicals are also important. Available records show that global mean surface temperatures have increased by 0.6 ± 0.2 ^{0}C over the course of the 20th century. Since 1976 a rate of increase of 0.15 ^{0}C / decade has prevailed. In the northern hemisphere, 1990s constituted the warmest decade of the last millennium. Extreme events in Asia pose the greatest problem for farmers and there are some indications that extremes are already increasing in frequency. Climate change can affect agriculture in a variety of ways. Beyond a certain range of temperatures, warming tends to reduce yields because crops speed through their development, producing less grain in the process. And higher temperatures also interfere with the ability of plants to get and use moisture.
The major cause of pollution, particularly in urban areas is the City Wastes and industrial effluents. The disposal of city wastes and sewage effluents has become a major issue in peri-urban areas. More than 450 cities in India generate more than 17 x 106 m3 of raw sewage per day. With available treatment plant the production of sewage sludge is estimated to be around 1200 tonnes per day. The application of industrial effluents to soil is governed primarily by the nature of its constituent's e.g. toxic element present in industrial effluents when applied to agricultural lands may enter food chain. However, industrial waste water could be used safely and effectively with proper precautions to increase soil productivity. The utilization of industrial effluents for agricultural purpose could also provide solution to their disposal problems. An attempt has been made in this paper to review the soil and environment related issues, their impact on human and plant life and their effective management by employing cost effective techniques.

Keywords: Global warming, rising temperature, biotic and abiotic stress, city wastes

Introduction
There has been a considerable increase in the average temperature of earth in the past century. This rise in temperature is attributed to the effects of global warming brought about by the accumulation of greenhouse gases in the atmosphere. This phenomenon is called Global Warming. The effects of global warming are numerous. The main culprits in the issue are excessive discharge of greenhouse gases in the atmosphere.
The greenhouse gases like carbon dioxide, methane, and nitrous oxide are playing hazards role in the present times. These greenhouse gases trap heat in earth's atmosphere and thus result in increasing the temperature of earth. The excessive emission of these gases is one of the major Causes of Global Warming. The major source of carbon dioxide is the power plants. These power plants emit large amounts of carbon dioxide produced from burning of fossil fuels for the purpose of electricity generation. About twenty percent of carbon dioxide emitted in the atmosphere comes from burning of gasoline in the engines of the vehicles. This is true for most of the developed countries. Buildings, both commercial and residential represent a larger source of global warming pollution than cars and trucks. Methane is more than 20 times as effectual as CO2 at entrapping heat in the atmosphere. Methane is obtained from resources such as rice paddies, bovine flatulence, bacteria in bogs and fossil fuel manufacture. When fields are flooded, anaerobic situation build up and the organic matter in the soil decays, releasing methane to the atmosphere. The main sources of nitrous oxide include nylon and nitric acid production, cars with catalytic converters, the use of fertilizers in agriculture and the

burning of organic matter. Another cause of global warming is deforestation that is caused by cutting and burning of forests for the purpose of residence and industrialization.

The gases append to the planet's normal greenhouse effect, permitting sunlight in, but stopping some of the ensuing heat from radiating back to space. Based on the study on past climate shifts, notes of current situations, and computer simulations, many climate scientists say that lacking of big curbs in greenhouse gas discharges, the 21st century might see temperatures rise of about 3 to 8 degrees, climate patterns piercingly shift, ice sheets contract and seas rise several feet. With the probable exemption of one more world war, a huge asteroid, or a fatal plague, global warming may be the only most danger to our planet earth.

Global warming related Issues

There is increasing evidence that global warming is caused by human activity: the release of greenhouse gases from burning fossil fuels, industrial processes and changes in land use. Of the man-made pollutants, carbon dioxide (CO_2) is the principal greenhouse gas, but methane, nitrous oxide and industrial chemicals are also important. Developed countries agreed in Kyoto in December 1997 to reduce their total emissions of greenhouse gases by 5% by 2010 relative to 1990 levels.

Reports indicate that global mean surface temperatures have increased by 0.6 ± 0.2 ^{o}C over the course of the 20th century. Since 1970 a rate of increase of 0.17 ^{o}C/decade has prevailed. In recent decades, warming has been most pronounced over the landmasses. In the northern hemisphere, 1990s constituted the warmest decade of the last millennium. The average global surface temperature in 2017 was 0.84 ^{o}C above the 20th century average of 13.9 ^{o}C (NOAA global analysis for 2017 accessed September 18, 2018). The warming has been greatest during the winter, spring and autumn seasons. Minimum temperatures have been increasing at approximately twice the rate of maximum temperatures, a phenomenon confirmed by many national scale. Projected warming in Asia is most pronounced in the winter. During winter, precipitation amounts are expected to decline significantly over many monsoon areas although Global Climatic Models (GCMs) do not suggest that the summer monsoon rainfall will decrease in reliability significantly. Extreme events in Asia pose the greatest problem for farmers and there are some indications that extremes are already increasing in frequency.

There are certain changes which are likely to continue in near future also. CO_2 concentrations will continue to rise, from around 360 ppm (parts per million by volume) at present to 450-600 ppm by the 2050s. CO_2 has beneficial effects on agriculture by encouraging photosynthesis and reducing transpiration. Globally, sea level will rise by 10-50 cm by the 2050s. Agriculture and settlements in low-lying areas could be affected by incursion of salt water into aquifers, coastal erosion and coastal flooding. If coastal storms become more intense and/or frequent the increase in combined risk of flooding could be significant. By the 2050s, the India is likely to be about 1-2 °C warmer than the present 1961-90 average. Winters are expected to warm more than summers. Higher temperatures increase evaporation rates, reduce frost hazards and winter chilling, lengthen the growing season and accelerate plant growth. Heat stress may affect many crops. Changes in precipitation (rainfall and snowfall) are difficult to calculate, but average seasonal changes are expected to be relatively modest (increases or decreases of 10%), at least until the 2050s. More rainfall is expected to fall in intense events, however, increasing runoff and the risk of erosion. Precipitation patterns might also become more variable, resulting in greater probabilities of floods and droughts - but this is still very uncertain. The combination of higher temperatures and changed precipitation regimes has implications for water balances and organic content of soils, with consequences for irrigation demand and use.

Effects of Global warming

The effect of global warming is increasing the average temperature of the earth. A rise in earth's temperatures can in turn root to other alterations in the ecology, including an increasing sea level and modifying the quantity and pattern of rainfall. These modifications may boost the occurrence and concentration of severe climate events, such as floods, famines, heat waves, tornados, and twisters. Other consequences may comprise of higher or lower agricultural outputs, glacier melting, lesser summer stream flows, genus extinctions and rise in the ranges of disease vectors. As an effect of global warming various new diseases have emerged lately. This disease are occurring frequently due to the increase in earth's average temperature since the bacteria can survive better in elevated temperatures and even multiplies faster when the conditions are favorable. The global warming is extending the distribution of mosquitoes due to the increase in humidity levels and their frequent growth in warmer atmosphere. The marine life is also very sensitive to the increase in temperatures. The effect of global warming will definitely be seen on some species in the water. A survey was made in which the marine life reacted significantly to the changes in water temperatures. It is expected that many species will die off or become extinct due to the increase in the temperatures of the water, whereas various other species, which prefer warmer waters, will increase tremendously. Perhaps the most disturbing changes are expected in the coral reefs that are expected to die off as an effect of global warming. The global warming is expected to cause irreversible changes in the ecosystem and the behavior of animals.

Global warming effects on Agriculture

The earth's climate has been relatively stable for thousands of years. We know that at a particular altitude we should plant a crop during a certain week of the year because conditions for it are just right then. For most of our memory as humans, our climates have closely oscillated around predictable patterns, and this has allowed us to feed ourselves and flourish. When a stable climate system is modified beyond its "tipping point," it gets out of balance and loses its equilibrium. While the system searches for a new set of patterns to stabilize around, variability and uncertainly are the norm. This, in essence, is the nature of the challenge that we are now facing. Agriculture is one of the most weather-dependent of all human activities. It is ironic, then that a significant percentage of greenhouse gas emissions come from agriculture. Fossil fuel-intensive agriculture is contributing to the creation of the unpredictable weather conditions that all farmers will need to battle in the not-too-distant future. Developing countries, many of which have average temperatures that are already near or above crop tolerance levels, are predicted to suffer an average 10 to 25 percent decline in agricultural productivity by the 2080s, assuming a so-called "business as usual" scenario in which greenhouse gas emissions continue to increase, according to the study. Rich countries, which typically have lower average temperatures, will experience a much milder or even positive average effect, ranging from an 8 percent increase in productivity to a 6 percent decline.

Individual developing countries face even larger declines. India, for example, could see a drop of 30 to 40 percent. Some smaller countries suffer what could only be described as an agricultural productivity collapse. Sudan, already wracked by civil war fueled in part by failing rains, is projected to suffer as much as a 56 percent reduction in agricultural production potential; Senegal, a 52 percent.

It has been widely recognized that developing countries in general stand to lose more from the effects of global warming on agriculture than do industrial countries. Most developing countries have less capacity to adapt than do their wealthier neighbors. Most are in warmer parts of the globe, where temperatures are already close to or beyond thresholds at which further warming will reduce rather than increase agricultural output. And agriculture is a larger share of developing economies than of industrial economies. But it has been difficult to estimate just how much individual countries are likely to be affected.

Climate change can affect agriculture in a variety of ways. Beyond a certain range of temperatures, warming tends to reduce yields because crops speed through their development, producing less grain in the process. And higher temperatures also interfere with the ability of plants to get and use moisture. Evaporation from the soil accelerates when temperatures rise and plants increase transpiration-that is, lose more moisture from their leaves. The combined effect is called "evapo-transpiration." Because global warming is likely to increase rainfall, the net impact of higher temperatures on water availability is a race between higher evapo-transpiration and higher precipitation. Typically, that race is won by higher evapo-transpiration. The following table, adapted from Cline's *Global Warming and Agriculture: Impact Estimates by Country* shows the range of likely impacts on agricultural productivity with and without carbon fertilization for rich countries and developing countries, and the totals for each.

Summary Estimates for Impact of Global Warming on World Agricultural Output Potential by 2080s (per cent)

	Without carbon fertilization	With carbon fertilization
World	-16	-3
Rich countries	-6	8
Developing countries	-21	-9
Median	-26	-15
Africa	-28	-17
Asia	-19	-7
Middle East- North Africa	-21	-9
Latin America	-24	-13

Based on Cline, William. *Global Warming and Agriculture: Impact Estimates by Country*, Table 7.1. But a key culprit in climate change-carbon emissions-can also help agriculture by enhancing photosynthesis in many important, so-called C3, crops (such as wheat, rice, and soybeans). The science, however, is far from certain on the benefits of carbon fertilization. But we do know that this phenomenon does not much help C4 crops (such as sugar-cane and maize), which account for about one-fourth of all crops by value.

There are those who argue that rapid technological change will raise agricultural yields so much by late this century that any reduction caused by global warming would easily be more than offset. But technological change is a false panacea for several reasons.

First, the green revolution has already slowed. Calculations based on UN Food and Agricultural Organization data show that grain yields, which rose at an annual rate of 2.7 percent in the 1960s and 1970s, have risen at only a 1.6 percent annual rate in the past quarter century. Although rising agricultural prices might provide incentives that would slow or reverse this decline, such a response is not assured. Second, even if there is no further slowdown, there is likely to be a close race between rising food demand and rising output. Global food demand is expected to approximately triple by the 2080s because of higher world population and higher incomes. It also seems quite likely that a sizable share of land will be shifted to the production of biomass for ethanol fuel. As a result, there is a rather precarious balance between supply and demand, which would be seriously worsened by a major adverse shock from global warming.

Impact of climate change on agricultural crops

The impact of climate change on arable crops, horticulture, weeds, pests and diseases, grasslands and livestock includes changes in the location of agricultural activities, earlier development and growth, changed yields and quality. Present and future climatic change is likely to have substantial impact on the production of all the crops depending upon the magnitude of variation in CO_2 and temperature. Increased temperature significantly reduces the grain yield and performance of a cropping system as a whole due to accelerated development and decreased time to accumulate grain weight. Rice yields are projected to decline by 5-12% over India and China with a further 2 ^{o}C rise in temperature and overall rice production in Asia could fall by just under 4% by the end of the present century. Wheat yields are also projected to fall in a similar manner and livestock farming will become difficult in some areas as pasture becomes less available.

Greater extremes of climate pose threats that are difficult to predict and adjust to but will, as of now, have large effects. A rise in sea level will have local but agriculturally important impacts, which may not be overcome easily by new crop varieties. High quality horticultural crops will be more susceptible to changing conditions than arable crops. Field vegetables will be particularly affected by changes in temperature. The availability of water is critical to the production of quality fruit and vegetables; a decrease in supplies will focus attention on increased efficiency of water use.

Disease transmission is likely to increase from greater exposure, e.g. from faster growth of pathogens in the environment and more efficient and abundant insect vectors. There may be consequences for food quality. The potential for soils to support agriculture, and the future distribution of land use, will be strongly influenced by changes in the soil water balance. Where soil water deficits increase, crop productivity will suffer, and for some crops this is likely to result in the increased use of irrigation. Soil organic matter levels will depend on the balance between carbon inputs to soils and the rate of loss resulting from decomposition.

Weeds evolve rapidly to overcome control measures. Very short-lived weeds and those that spread vegetatively evolve fastest. The rate of evolution will increase in hotter, drier conditions and in 'extreme' years. This increased rate of evolution could lead to some types of herbicide tolerance becoming more common. Predicted climate changes are likely to increase the range of many native pests and diseases but decrease the range of others. Native species that are not currently economically important may become so, while the significance of other pests and diseases may diminish. Surveillance and eradication procedures for some alien pests and diseases are likely to become increasingly important

Farm management will be affected by climate change. Soils, climate, markets, technology, capital and policy all influence the location and type of farming. In determining future cropping in a warmer climate, it is extremely important to take into account increased climatic variability and the pattern of rainfall (amount, distribution and intensity). Unfortunately, these are the hardest features of climate change to predict. Increased climatic variability will require closer crop monitoring, scheduling of work peaks to ensure that crops are harvested and established in the appropriate conditions, and provision for greater fluctuations in markets and income. The impact of climate change depends on the mix of global effects on demand and production and the local effects of warmer temperatures and altered growing conditions. The policy and economic framework for Indian agriculture could significantly mitigate the impact of climate change. Significant uncertainties remain in our understanding of climate change, its impacts and the most effective responses.

Drought

The major impact of climate change is frequent occurrence of agricultural droughts in the season and long dry spells during cropping season which ultimately lead to tremendous decline and uncertainty of crop production on large scale. The drought may be defined as periods in the natural cycle of stress and renewal during which the amount of moisture in the soil no longer meets the needs of a particular crop. Water is important to crops (and so badly missed during a drought) because it acts as biochemical reactant, it is a medium/solvent in which many biochemical process takes place, generates turgor pressure, which provide strength to leaves and helps in evaporative cooling. With all these critical roles, it is obvious why water shortages can be detrimental to crops.

Drought stress can affect number of physiological/ developmental processes. These include LAI development. Under drought stress, fewer and smaller leaves will typically be formed; and leaf area duration may be reduced (because of senescence of leaves). Roots interestingly show a very different (but very logical, from a survival standpoint) response. Root growth is often accelerated by at least moderate drought stresses. In case of legume crops, the severe drought conditions can reduce their ability to fix nitrogen. Flowering can be delayed, and the number of flowers or fruits can be reduced. Drought stress during the time of reproductive development is especially bad news for a crop. A series of studies have shown that short periods of severe drought stress during vegetative stages are rather inconsequential on yield. On the other hand, three or four days of severe drought during early to mid-reproductive stages (with water relations being good all the rest of the life of the crop) can reduce yields by 50% or more. For maize, the time of silking (when pollen is to be shed) is most critical. For soybeans, drought during pod fill (when seeds are growing most rapidly within the pods) is a real “killer”. For rice and wheat, the most sensitive period appears to be right before heading (when the grain head first appears). Drought during that time may reduce potential yields by 50% or more due to reduced formation or abortion of florets (which are the potential grains). Drought stress during the grain fill period of most crops is very crucial because that is when most of the dry matter to fill the seeds must be made. Once a crop reaches physiological maturity, drought stress does not have adverse impact on yield. It is because at this stage the seeds have reached maximum dry weight (the definition of physiological maturity),

An imposing 70% of the cropped area in India is under rainfed conditions where water availability is the most overriding limitation for achieving potential crop productivity. An estimated 30-70% yield loss in various crops occurs due to drought. Any efforts therefore to mitigate drought could substantially contribute to enhancing food production of the country.

Alleviation of drought effects on plants

Drought effects on plants can be minimized/reduced to a greater extent by adopting various cost effective techniques. These include scientific land and rain water management. The land and water management practices should aim at conservation, protection, preservation and efficient utilization of land and water resources. Location specific practices which tend to control soil erosion enhance surface as well as internal drainage and conserve soil profile stored moisture e.g. soil mulches, bio mulches, and increase soil organic matter content and drastically cut down the evaporative losses must be preferred to minimize the drought effects.

Remedies

To mitigate adverse impact of climate change, studies are being taken up at large scale in India and other countries. Results so far obtained indicate that to some extent the adverse impact of climate change can be overcome by changing the agronomic practices such as shifting of planting time and use of varieties with different phenology. Nevertheless, farmers should consider three strategies;

i) Maintain or enhance their ability to adapt to change.
ii) Anticipate climate change in some decisions.
iii) Take steps to reduce emissions of greenhouse gases.

Alleviation of the impact of high temperature

The planting time of the crop species should be such that its growth and development gets the required optimum temperatures. Planning of more than one variety of a crop with different maturity can help in reducing the risk of uncertainty of occurrence of high temperature stress and yield losses. In case high temperature conditions prevail along with severe soil moisture conditions, the impact will more pronounced. Therefore, under such circumstances providing irrigation could help in lowering the high temperature effects on the crops.

City wastes and sewage effluents

More than 450 cities in India generates more than 17 x 106 m^3 of raw sewage per day. With available treatment plant the production of sewage sludge is estimated to be around 1200 tones per day. Although, there exist potential to produce 4000 tonnes of sludges per day. The nutrient potential of available sewage in India is estimated to be more than 350,000 tonnes Nitrogen, 150,000 tonnes P and 200,000 tonnes K per year (Juwarker *et al*., 1991). During last couple of decades, land application of waste water is being reemphasized as an alternative technology for waste treatment. The application of industrial effluents to soil is governed primarily by the nature of its constituent’s e.g. toxic element present in industrial effluents when applied to agricultural lands may enter food chain. These may also leach to ground water or reach surface waters through run off and deteriorate their quality.

The disposal of city wastes and sewage effluents has become a major issue in peri-urban areas. Sewage is the most general term used to define all kinds of liquid wastes produced in a community. It is the liquid form of residential and industrial establishments of a town. It is made up of spent water from bath room, lavatory, basins, kitchen, sinks and the discharge from the urinal and home, offices and institutions, human and animal faeces. The sewage is extremely foul on account of human excreta and urine content in it, which putrify and gives out offensive smell.

Average composition of sewage

Allowing the waste water to be cleaned by percolation through soil or dumping sewage sludge on agricultural lands, it must be ensured that these do not leave undesirable residues in the soil. In this regard, the characteristics of wastes assume great importance. The composition of sewage wastes is highly variable depending upon the contributing source, method of collection, and treatment procedure. The composition of sewage waste water from a sewage farm Ujjain and Indore districts of the state of Madhya Pradesh has been reported by Shrivastava and Singh (1990) and Bangar *et al.* (2007) [4] as presented in Table 1. In India most of the raw sewage is the mixture of domestic, commercial and industrial activities. Therefore, a large proportion of this waste water is organic in nature and contains essential plant nutrients, sometimes toxic elements are also present in considerable amounts. The municipal waste waters contain conspicuously high amount of organic matter. The composition of waste water also varies with season. The raw sewage has only about 0.1% solids and 99.9% water. The organic and inorganic constituents in the solid fraction are in ratio of 70:30. The inorganic constituents include grit, salts and metals while organic substances are proteins, carbonates and fats.

Table 1: Composition of sewage waste water from sewage farm Ujjain and Indore

Parameter	Ujjain	Indore
pH	7.4	7.4
Conductivity (dS/m)	2.2	1.02
Nitrogen (µg /ml)	54.0	57.0
Sodium (mg /L)	117.0	64.4
Potassium (mg /L)	63.0	28.0
Cadmium (mg /L)	0.05	0.03
Zinc (mg /L)	4.00	0.08
Chloride (mg /L)	412.0	152
Total dissolved solids (mg /L)	1500.0	653.0
BOD (mg /L)	816	85
COD (mg /L)	250	260

Bio-remedial and physical measures for the treatment of Waste Water

There are bio-remedial measures as well as physical measures are available for treating waste water and then its use for various purposes. Cost effective physical measures include natural filters of sand, sand + metals and sand + boulders while bio-remedial measures are growing of appropriate grasses and other plants with an objective to reduce contamination of wastewater for agricultural and other purposes. The use of bio-remedial material (Reed grass) and physical materials (sand, sand + metals and sand + metals + boulders) has the capacity to reduce the BOD and COD load of the sewage effluents to a greater extent.

Industrial effluent and soil pollution

The industrial effluents are generally discharge on land or into sources of water. These effluents have variable characteristics and metal content that may prove harmful to soil environment. This causes soil degradation and environmental pollution. Besides being a source of plant nutrient (N, P, K, S etc.), these effluent often contains high amount of various organic and inorganic materials and toxic trace elements. These may accumulate in soil in excessive quantities on long term use. Subsequently, these toxic element cause physical problem to human being and animal by entering in to the food chain. However, industrial waste water could be used safely and effectively with proper precautions to increase soil productivity. The utilization of industrial effluents for agricultural purpose could also provide solution to their disposal problems.

Management of waste water use in agriculture

The use of wastewater in agriculture is a centuries-old practice that is now receiving renewed attention with the increasing scarcity of fresh water resources in many arid and semi-arid regions of the world. Driven by rapid urbanization and growing wastewater volumes, wastewater is widely used as a low-cost alternative to conventional irrigation water: it supports livelihoods and generates considerable value in urban and peri-urban agriculture despite the associated health and environmental risks. Due care must be taken while using waste water for agricultural purpose. The major precautions for its use include;

1. It should not be used directly to leafy vegetables to avoid heavy metals contamination in it.
2. The waste water must be treated with different treatment methods after wards it should be used to irrigate orchards, lawn and grasses etc.
3. Its use may be done in a scientific manner and dilution may be done before its use in agriculture.
4. Waste water must be diluted with the good quality irrigation water.
5. Proper care should be taken to use such waste water in coarse textured soil because its heavy use may pollute the ground water adversely.
6. Waste water management consists of two parts: Treatment of waste water and recycling of treated water.

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