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A FOCUS ON MAN'S INTERFERENCE WITH HYDROLOGIC CYCLE IN WATER RESOURCES DEVELOPMENT

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ABSTRACT

The paper selectively highlights the influence of man on various elements of Hydrologic Cycle. The major activity of Man which affects the process is due to abundantly increasing Land-use for the rapidly increasing population of the World i.e. repercussions of rapid urbanisation.

The author enumerates diagramatically various man-made elements which exert influence on the Hydrologic Cycle. This indicates the complexity of the problem which had not been considered seriously in earlier times.

Further, the author has pointed out some important effects on 'Climate' and ' Atmosphere' revealing interesting information.

The interference on river regimes has been pointed out. The adverse effects of Water Projects (1)(2) more pointedly on the hydrology of the land are highlighted.

The role of UNESCO IHP II and III which widely embraces relevant studies has been described exhaustively giving World-wide situation as surveyed by United Nations FAO experts on the Working Group.

1.INTRODUCTION

Man's overall impacts on elementary hydrologic cycle today are the greatest than that at any time in history. Man's (3) initial actions commonly trigger a chain and affect relations and Synergistic feedbacks within the total environmental system. The second, third and higher order effects are usually unanticipated and often threatening.

A deeper study of the human impact within a broader environmental context is indeed called for. It would require to deal with additional topics of 'Air' and ' Water pollution' but in the present scope of the Paper, the author confines himself selectively to the processes and points which concern

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FIG. 1. ELEMENTS OF MAN'S INTERFERENCE

the hydrologic cycle only.

The most important influence of Man on hydrologic cycle is exerted through the use of Land. It becomes therefore necessary to study the hydrologic effects of Land use.

For instance, increased flood magnitude consequent upon forest clearance and land-use-change clearly demonstrate the impact of Man on hydrological and chemical processes. Many of the changes brought out by Man's activities are also detrimental in the broader environmental fields. Recognising many detrimental effects of human activites on environmental processes points out the need to assess the potential impact of future activity to regulate/or modify this effect accordingly. The Environmental Impact Assessment(EIA) has evidently become a useful tool. The author brought out a Paper[4] elsewhere on EIA in case of impact of Urbanisation and Industrialisation. Attention is being paid to these problems at international level. The paper focusses attention selectively on the significance of human impact on the process of Hydrologic Cycle.

2. MAN'S INTERFERENCE WITH HYDROLOGIC CYCLE

In a paper at this level there is no need to start fundamently or define a Hydrologic Cycle. It is known that the Hydrologic Cycle is subject to various complicated processes (5) of Evaporation, Precipitation, Transpiration, Interception, Infiltration, Percolation, Storage and runoff. At some stage or the other usually there occurs transportation of water : temporary storage, change of state (from vapour to liquid or solid) also. It is known that the quantities of water going through the individual sequences of the cycle can be estimated by the so-called hydrologic equation defining the process, i.e. $I - O = \Delta S$

in which

I = inflow of water to a given area during a given time period

O = Outflow of water from the area during selected time period.

ΔS = change in storage of the volume of water in or on the given area during the time period.

The author presents in Figure 1 the Hydrologic Cycle and the likely elements of Man's influence on it. The numerously increasing Man-made activities, some of which are listed in the bottom of the Figure 1 are considered to change the Environment and Ecological balance, the extent to which interference occurs depends upon the geohydrological conditions and geographical situation of a country.

Giving an idea of the total global water balance here seems desirable. The global water balance (6) (volume in cm. per year) is said to be for 'Oceans' and ' continents' as precipitation 112 and 72 : (runoff -13) : as Evaporation 125 to 41 (runoff 31) respectively. For whole Earth the precipitation 100, Evaporation 100, runoff zero.

For Asia precipitation 61, Evaporation 39, Runoff 22 cm./year.

The total quantum of water in the form of liquid gas and ice/snow on the globe remains the same according to the Law of Conservation of Mass. The basic phenomenon of the hydrologic cycle runs through the same processes but the processes get affected by Man-made changes to a degree depending upon the magnitude of the Man-made barriers on the natural regime of flow of water on Earth. Sometimes Man's activities e.g. random attempts of exercises and experiments for artificial Rain, Cloud condensation, explosion tests, weather modification and over exploitation of ground water storage makes a direct impact on the processes of the Hydrologic cycle.

3. EFFECT ON CLIMATE/ATMOSPHERE

It is axiomatic that an increase in the number of people increases the magnitude of Man's environmental impact. Man's interference on Water Cycle, climate, atmosphere, through a number of factors though very small to cause a change but being significant enough, encompass the following :-

* indirect climate changes
* impact on water
* urban effects on hydrology and climate
* effects on atmosphere
* increasing frequency and or magnitude of a given kind of impact
* impact on land and soil and on destruction of vegetation etc.

Prominent among these can be the hydrologic effects of Urban Land Use. It is well recognised that the cities cause local but severe changes in the hydrologic cycle. Urbanisation greatly increases the percentage of lands surface which becomes impervious to water. Infiltration reduces and high proportions of precipitation runoff goes to streams causing increased flooding than normally otherwise. Despite considerable research done in Urban Hydrology and its effect on hydrologic cycle there are still gaps in our understanding.

Hydrological cycle is associated with atmosphere, extent of Man's impact on atmosphere is now global. We have inadvertently changed the composition of air not just within cities or regions but in countries. There is evidence that air pollution is associated with certain changes in global climate. Reid Bryson(8) discussed processes by which man's alteration of two atmospheric components, carbon dioxide and dust may be changing the Earth's climate. From 1880s to 1940s the average temperature of the world rose by at least 0.7°F. Carbon dioxide content increased by 11 percent. However after 1940 the world began to cool off and by 1960 cooled about 30 percent of the previous rise, but CO_2 concentration continued to increase. Additional mechanisms of climatic change by pollution may also operate at the global scale. Increased cloud cover caused by pollutants acting as

condensation nuclei might cause cooling by increasing reflection . Contrails from jet planes are one such type of man-made clouds. Contrails in the atmosphere, produced by supersonic planes may be persistent and climatically dangerous. The results of man-made climatic changes would be far reaching and may change agricultural potential. Most importantly resulting changes in Sea level would affect coastal culture resources and erosion.

4. INTERFERENCE WITH SURFACE FLOW

Rainfall varies due to many meteorological and hydrological conditions. Floods or droughts occur. In olden times before Man embarked upon harnessing the surface water resources by construction of River Valley Projects, the flow in streams and River Basin catchments used to be natural under certain long existing hydro-meteorological conditions of the Water Cycle depending upon the location of a country on the globe. The creation of reservoirs by constructing thousands of Dams high and medium in the past 3-4 decades in developed and developing countries, man made storages, large scale irrigation networks and huge water transfer systems have changed the natural river flow regimes affecting environment acutely and have been considered as major cause for interference with the nature's hydrologic cycle.

The evaporation and evapotranspiration can be said to be two very important elements of the Cycle which have progressively been affected due to increase in Water spread areas as a result of Man-made reservoirs, increase in irrigated agricultural areas, vegetation etc. Wherever Dams, Barrages and obstructing structures on rivers have been built, the river regimes get affected and hydrology differs under post-project conditions. The consequent environmental/ ecological changes have indirect effect on the Water Cycle which increases with the rate of human interference with flow of water.

5. WATER PROJECTS IMPACT ON HYDROLOGIC CYCLE'S ENVIRONMENT

Among numerous ill effects (1) (2) of Water Projects those such as causing Water logging, seepage, leakage in large Water Conveyance Systems, ill managed drainage in agricultural fields, problems of storage of surface waters, environmental changes and ecological imbalances due to human interference with natural river flow systems to result in perceptable change in river regimes have invariably interfered with the Hydrology of the region. These upsetting elements have been indirectly responsible, to some extent, in influencing some of the major elements of the Hydrologic cycle. It has been seen that the development of reservoirs and other systems of water resources use and management can seriously alter the natural flow regime, often detrimentally.

6. UNESCO'S ACTIVITIES ON HYDROLOGICAL CYCLE

UNESCO (9) has been very active in implementing IHP II and III Programmes which contains studies in Hydrology covering almost all the aspects, including indirectly those which infer with human interference with the hydrologic cycle, in the developing countries under ROSTSCA region in South and Central Asia. More prominent programmes/studies related to the understanding of interference with natural Hydrological Cycle and its elements as studied in various countries under IHP II and III include : Hydrology in environmental management and development: Hydrological aspects of climate variability and of weather modification: Monitoring natural and man-made changes in the various hydrological regimes (Project 6.1) : Man's influence (land use etc.) and climate variability on the hydrologic cycle stream flow and ground water (Project 6.3): Effects of urbanisation on hydrological cycle (Project 8.4) : results in symposium 1978 will be consolidated in the planned symposium in 1988. Earlier, under IHP II (10), Project 5.1 dealt with assessment of quantitative changes in the hydrological regimes of river basins due to human activires (1975-1980) and the out come of Working Group established for prepration of case book. The author will not reproduce details here due to space limitations. Furthermore, the results of studies of Project 1.1 undertaken (WMO Collaborated) during last 2 decades have demonstrated that the atmospheric vapour flux may serve as an effective indicator of the total hydrological cycle including its terrrestrial component.

One of the research themes of MAB programme concerned with impact of human activities on dynamics of arid and semi arid zones, ecosystems and desertification aspects: also World's Climatic Programme has orientation to hydrology and its cycle. Other international bodies associated with allied activities on hydrology in coordination with UNESCO include WMO UNDP,UNEP,FAO, and IAHS,IAHR,IAH,ICID and IWRA etc.

7. A GLIMPSE OF WORLD-WIDE SURVEY

Pereira H.C.(11) Chairman FAO working group of IHD and Study of Influence of Man on the Hydrological cycle' after a World-Wide Survey gave his concluding recommendation on this aspect. In developed countries methods of Watershed protection and Soil conservation are successfully adopted but in developing countries, these are failing at an alarming rate as natural watershed cover is destroyed both problems arise from rapidly increase in rate of human population. The vitally important information on Global basis on the major fields of man's activities which affect the Hydrological cycle as considered by him are summarised below :

* Meteorology : It measures major inputs to hydrogical cycle. Advances in technology of photography of cloud patterns over half of the planet from satellites in space mapping rain fall by radar, weather data collection by computers all have offered new and powerful methods of study. But man's ability to exert direct influences on pre-cipitation is yet small and restricted to cloud seeding in limited areas.

* Construction Engineering: Man's major intentional interventions in the hydrological cycle have been carried out by construction and operation of weirs, dams, barrages, canals, reservoirs built to divert to transport and to store water, thrbughout history.

* Hydrological effects of land use: The major influence of man kind on Hydrological cycle has been and is still continuing to be due to the ever increase in use ofland by Man with the rapidly increasing human populations. Man occupied land and converted vegetation and soils to his own use without consideration of the hydrological consequences. These hydrological consequences have not been recognised till recently , even when floods, droughts, soil erosion or salinity brought disaster to the communities causing them. The classical land use mistake is still being repeated by developing countries unable to cope with the problem of increasing population.

* The hydrological influence of Man: through his use of land in watershed areas was further reviewed by Pereire under the ecological classification of forests : grass lands : arable lands: irrigated agriculture: and industrial urbanisation which though remarkably relevant to the subject will not be gisted here due to space limitations.

The author is of the view that there is need for carrying out case studies to assess more realistically the effects of impact of Man's influence on Hydrological Cycle.

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