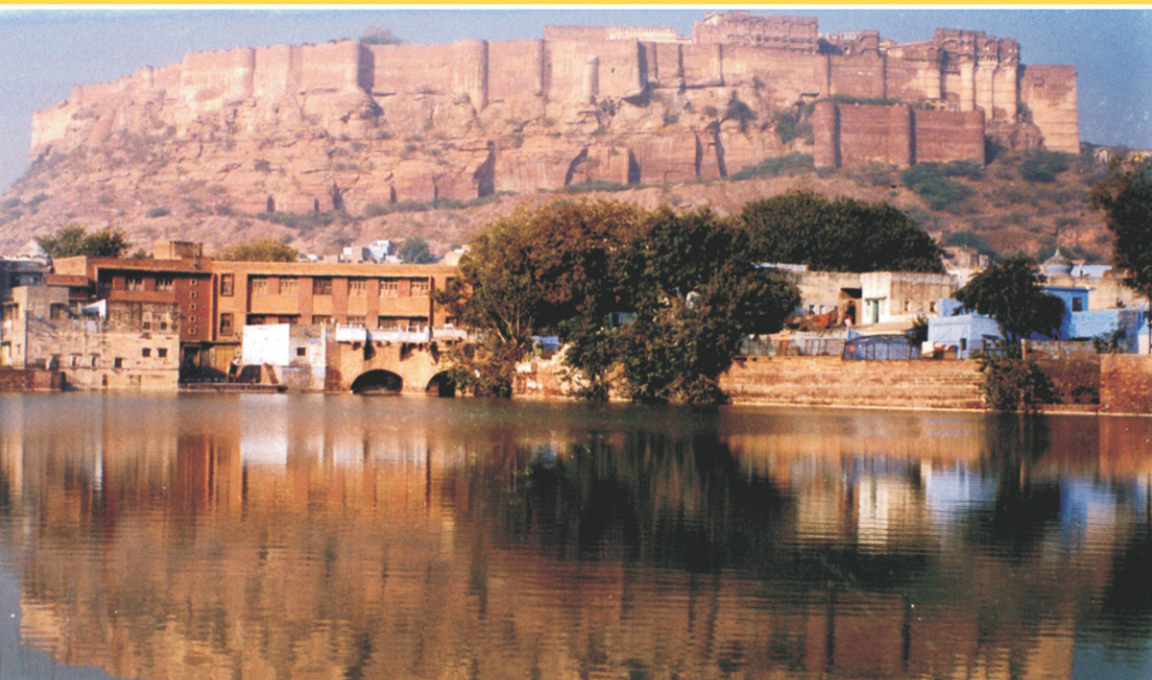


Global Groundwater Resources and Management



B.S. Paliwal





Global Groundwater Resources and Management

*Selected papers from the 33rd International
Geological Congress (33rd IGC), Oslo, Norway,
August 2008*

Edited by

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Dedicated to



Shubham

*my inspiring Grandson
who is always ready for
the assistance*

— Prof. B. S. Paliwal

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**INTRODUCTION: GLOBAL GROUNDWATER RESOURCES
AND MANAGEMENT****B.S. Paliwal**

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1. INTRODUCTION

Water- the basis of life and an absolute necessity for all its varied activities on this living planet has a prolonged geological history associated with the cooling and condensation of the nebular mass giving rise to our solar system, of which the earth itself is one of the orbital, members. The origin of water on the earth crust predates the appearance of oxygen in the atmosphere. Perhaps life originated in water about 2.9 billion years back when our atmosphere totally lacked in oxygen (Strahler, 1981). It was only about 2.4 billion years ago when oxygen releasing blue-green algae evolved and its profused growth helped the atmosphere getting enriched in oxygen. Since then water has established its significance as an important parameter of the biosphere as a whole.

Man has maintained an intimate relationship with water since beginning. Archaeological excavations also support the fact that the very first clustering of the Preolithic man took place along ancient river banks. Its importance has increased many times with the advancement of science and technology, industrialization and green revolution in the world. Even in the modern scientific era-the space age, we are totally and absolutely dependent on this primitive but vital natural resource (Paliwal, 1989).

2. EXHAUSTING NATURAL RESOURCES

Natural resources on the earth, whether they are minerals, forests, fossil fuel or groundwater, all are limited and can not withstand long the present rate of exploration by fast growing population with increasing consumptive attitude. Their exploitation is directly linked with the growth rate of human population and developmental activities whether it is industrialization, green revolution or efforts to improve living conditions in the society. Integrated use of natural resources is a complex and long term problem inviting international cooperation and interdisciplinary approach. Optimum utilization and conservation of natural resources have now stepped over regional and national boundaries and have become a global issue. Strive for maximum exploitation is often stronger than moral responsibility towards conservation and protection of natural resources. We are answerable to our coming generations for destroying natural environment of the globe and excessive consumption of our natural resources including groundwater. For this very reason, we may appear to our descendants to be creatures lacking any fundamental ideas (Vrba and Moldan, 1984).

3. WORLD POPULATION PROFILE

The growth rate of human population in the world particularly in the third world countries is a matter of serious concern and if we worry about it, then we have the right to do so. The world population has exploded only during the last a few decades. It took a few million years, since man has established its separate identity in the animal kingdom, for the world population to grow one billion by the year 1850, but in short period of 80 years since 1930 it just doubled and by the end of twentieth century, in another 70 years it was again tripled. By the year 2030 world population will be 8.6 billion (Howard, 2007). Such a mammoth human population will require a large quantity of water and that could be met out with better management of water, both surface water and groundwater. United Nations Organization in its recent report has alarmed the world against population explosion. According to the report, the world population will touch a figure of 14 billion by the end of the 21 century if adequate measures are not taken up well in time to check this steady and alarming increase in the human population on this globe. Of course the world population can not decline at the most the present rate could slightly be reduced by spreading awareness in the society and by applying adequate scientific methods. An overall attitudinal change in the society is badly needed. Developing countries like India and China are facing a population crisis that has hampered all the efforts being made for the development.

4. STATUS OF GROUNDWATER RESOURCES

Water available on the earth crust is of the order of 1.4 billion cubic kilometers, of which 97.3 percent is shared by the oceans. More than three-fourth of the remaining 2.7 percent fresh water is in the form of glaciers and polar ice. Merely 0.36 percent of the world water resources is available for the human consumption.

in the form of rivers, lakes and other surface water reservoirs. Groundwater makes up about 98.5 percent of the unfrozen fresh water present on the earth crust. Of course periodic monsoon and melting of snow accumulated in the hilly areas above the snow-line are the only source of fresh water on the surface. On the other hand present groundwater resources of the world, which took a long geological time to accumulate are also the product of rain water/ surface water of the past.. In fact a very large amount of the total precipitation in an area is either evaporated or goes waste as run-off and a very small quantity of it percolates down the surface to reach aquifer and stored as groundwater reserve, that too when the hydrogeological conditions favour it. Therefore, all the groundwater reserves that we have explored today, in fact, have taken a long time to take present shape. Fossil groundwater from some of the areas has been reported to be several thousand years old (Paliwal, 1999)

5. CONTAMINATION AND POLLUTION OF GROUNDWATER

Fortunately, as a renewable natural resource, groundwater is subject to a continuous discharge and recharge process. It has two great advantages over the surface water reservoirs: (i) it is protected from direct evaporation and (ii) it is not easily polluted, except in agriculturally and industrially advanced countries having shallow aquifers.

The shallow circulation accessible to human activities is the main cause of its high vulnerability to contamination. Pollution of groundwater as a result of industrialization, urbanization and green revolution is yet another problem further deteriorating low availability and high demand conditions of the groundwater resources in the world. Because of its high dynamic mobility and a very high ability to absorb, transform and transport the pollutants, has made it as one of the most dangerous contaminating media. About 80% odd diseases are one way or the other related to the contamination or pollution of water. Surface and groundwater interaction plays a significant role in contaminating groundwater (Paliwal and Baghela, 2007). At times the geochemical composition of the aquifers also helps in contaminate the groundwater as is the case with fluoride, nitrate and arsenic (Paliwal, 1999).

6. FUTURE REQUIREMENT AND MANAGEMENT OF GROUNDWATER RESOURCES

Increase in the industrial and agricultural produce to meet out the needs of an overwhelming world population , consumption of both surface and groundwater resources has also increased rapidly during the last a few decades. The European Economic Commission in its report has clearly mentioned that the world annual water intake amounting 400 cubic kilometers per annum in the early 20th century has increased to 1100 cubic kilometers per annum by the end of 1950 and more than 3000 cubic kilometers per year by 1980. The world consumption of water by the end of the 20th century will be of the order of 5500 cubic kilometers per annum. In future we will need more water and a better

management of surface and groundwater resources which are limited until we discover deep seated groundwater reserves in unexplored areas of the world.

7. ARTIFICIAL RECHARGE OF GROUNDWATER RESOURCES

In the absence of a proper planning and a better water management, most of the rain water is either polluted or carried by rivers to the oceans, unused. A situation of flood in one part and draught in other in many parts of the world, similar to that in India, prevails. Rivers when flooded cause en-masse killing of inhabitants and livestock in the flood prone areas and a gross damage to the standing crop worth millions of rupees and the fertility of the soil. This surplus surface water could be trapped and used for artificial recharging of groundwater through faults, lineaments and palaeochannels. Floods are not restricted to areas of heavy rainfall only but they occur in the arid regions too, because of a poor drainage system. Barmer flood of 2006 in western India is an example of such a situation.

8. ROLE OF THE SOCIETY

Obviously, we are likely to face an acute shortage of water especially drinking water and a crisis its management. In the near future, neither new water resources are going to be evolved so quickly nor the existing frequent flood and draught conditions are likely to change dramatically. Of course, we expect some hidden deep seated groundwater reserves. In these circumstances, the only alternative left with us is a better groundwater management system evolved through a change in the attitude of the society towards its utilization, protection and conservation. This could be possible if we are able to spread awareness in the society through education.

First of all, we have to educate ourselves so that we can speak to our leaders, politicians, policy makers and people in a way they understand us and realize the importance of conservation of groundwater resources. If we could teach our politicians the necessity of planning nature and its various recourses including groundwater, not only for a few years up to the next elections of assemblies and parliaments, but for the long perspectives, then every thing would be under control (Konigsson, 1984). It is unfortunate that our societies of all political systems, particularly in the developing countries, do not treat natural recourses and environment so seriously and respectably as they should. On the other hand people in the developed countries simply end their duty by accuse the third world. Planning, consumption, conservation and management of groundwater resource should be the integral part of a country's government policies.

At the first level of teaching and education we will have to make our leaders, politicians, policy makers and people en-masses to understand the gravity of the problem. All of them are to be convinced that the present population of the world can not diminish now, at the most its growth rate could be checked, that too up to a certain extent only and for more people we will need more food, more resources, more water and a better management. On the other hand groundwater resources are limited and exhausting rapidly therefore, to

induce an attitudinal change in the society, the curricula for the mass education, the distant education and the adult education to be spearheaded through radio talks, television programs, articles in the news papers and magazines, exhibitions, film shows, public speeches, seminars and work shops, should include the necessity of the awareness in the societies of all political and religious systems.

The most important aspect is that if we want an attitudinal change in the society towards natural resources and groundwater in particular, then we will have to teach our children, the future citizens, during early school years, the importance of treating the nature with humbleness and that they must know that they will have to treat the nature in a way that it continues to support them, then only they can have a future brighter than the present.

Its high time to realize that the earth as a whole is one and every individual born on the mother earth has an equal right on its resources including minerals, agricultural produce and water both surface and groundwater irrespective of caste, creed, religion or political boundaries.

9. ABOUT THE BOOK

“Global Groundwater Resources and Management”

The book on “Global Groundwater Resources and Management” has been aimed at growing recognition of depleting world groundwater resources, their contamination, future requirement of the fast growing human population of the world and urgent need of a better groundwater resources management system.. The issues are quite complex but now they have crossed all the political boundaries and have become a common cause. The biggest challenge before the scientific community is to integrate valuable scientific advances and technological progress to solve the issue based on holistic and effective sustainable groundwater management. The book comprises the selected papers presented from all over the world at the 33rd International Geological Congress, Oslo, Norway, August 6-14, 2008.

A referee system of very high international standard including as many as 67 internationally recognized subject experts was adopted to review all the papers thoroughly before accepting papers finally for the publication. Each paper has been reviewed by at least two internationally recognized subject experts. In many cases as many as 5 or 6 subject experts have been contacted for the review work for a single paper not because of any adverse comments but because of a much delayed response from the first two reviewers. As a result other two subject experts were consulted and the papers were sent to them for the review and so on. Fortunately, all of them have sent their review comments simultaneously but at a later date. We honoured comments of all the reviewers and requested the authors to modify their papers as per comments of all the reviewers.

The book is broadly divided into five sections dealing with key aspects of global groundwater resources and management

1. Groundwater Resources and Management
2. Hydrogeological Conditions, Groundwater Assessment and Modeling
3. Hydrogeochemistry and Contamination of Groundwater Resources
4. Exploitation of Groundwater and Recharge
5. Hazardous Groundwater Conditions

In total 31 research papers of scientists from Argentina, Australia, Bangladesh, China, Finland, Greece, India, Italy, Mexico, Netherlands, Oman, Poland, Portugal, Russia, Serbia, Turkey and Uzbekistan were selected from the General Symposium: Hydrogeology of the 33rd I.G.C. Oslo, 2008. Reviewers were internationally recognized subject experts from countries like Argentina, Bangladesh, China, Finland, Greece, India, Indonesia, Italy, Japan, Poland, Portugal, Russia, Serbia, Syria, Thailand, Turkey, Uzbekistan and United Kingdom.

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Section – 1

Groundwater Resources and Management

