CONJUNCTIVE USE - COPING WITH WATER LOGGING AND SALINITY

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ABSTRACT

The increase in irrigation potential through the construction of major and medium dams along with the network of canal systems for water distribution gave the food security but there was unintendedfallout in the form of water logging and salinity. These two problems (water logging and salinity) have now become perpetual in nature and their aerial extent is increasing over the years with no action plan to mitigate them other than selective improvement of drainage system.The problem of water logging was first noticed in 1850 in West Yamuna Canal area and in 1884 in Nira Irrigation Project area, clearly indicating that the water logging problem is inbuilt with the irrigation projects which result because of seepage from lined/unlined carrierchannels,applied irrigation& overuse of surface water, less utilization of groundwater than its annual recharge and in some cases because of the presence of sub surface lithology dominated by clay matrix. The areas under water logging was estimated by CGWB in 1999 and observed that areas in Punjab , Haryana ,UP and Rajasthan covers 1.05 lac sq km andsalinity in about 1.45 lac sq km (data requires updating)showing the seriousness of the problem which has converted large area non productive. Earlier estimates indicated water logging, salinity and alkalinity cover about 14,250 sq km , 30,694 sq km ad 12,780 sq km respectively under irrigation projects . The conjunctive use of surface water and groundwater (fresh or saline) is being adopted by a number of countries for achieving proper irrigation returns and solving problems of water logging . Moreover, conjunctive use is likely to be critical and a necessary option as water resource adaptation measure under the projected impact of climate change and recovering vital fertile areas for food security.

INTRODUCTION

The introduction of surface water irrigation and the creation of surface water drainage caused a positive change in the groundwater balance . Along the canal system for water distribution , the disposition of different lithological units and the aquifer system thereof proved unable to dispose of all the additional recharge by natural outflow which caused building of underground storage resulting in continuous rise of water table ultimately resulting in water logged conditions. Agriculture Commission 1996 recommended measures to prevent and remove water logging by (i)Effective drainage (ii)Conjunctive Use for surface and ground water (iii)Improvement in Irrigation Water and Application(iv)Efficient Irrigation Water Management.

Out of different options recommended for anti-water logging measures , conjunctive use looks to be the best option . Conjunctive Use isgenerally defined as a coordinated and planned utilisation of surface and groundwater and gives the advantage of utilizing groundwater storage and surface water availability. It not only provide the best possible solution as a anti water logging measure but also provides additional water for increasing the intensity of irrigation and availability of more water in the tail end reaches .

PROBLEM OF WATER LOGGING AND SALINITY

There is no denying the fact that the water logging problem emerged mainly as a direct affect of seepage from applied irrigation and from the large scale canal systems .But it can also be caused by to some extend by excess soil moisture due to periodic flooding, overflow of run-off , seepage ,artesian water and obstructed sub surface drainage .

The irrigated areahas increased from 22.5 m ha to 54 m ha ;the irrigation potential also increased from 22.61 million ha in 1950 to 106.06 million ha to 2010 and the food production has also increased to about 220 m tonnes in 2010. But the increase in irrigation area was also associated with the unintended fall out in the form of water logging and salinity .

Adverse effects of canal irrigation system i.e. water logging in Western Yamuna Canal(Haryana) was first received attention in 1850 , followed by Nira Irrigation Project in the Deccan in 1884.By 1907 , waterlogging problem was noticed in the canal of Punjab .In Punjab , the water logged area was estimated to be (1.09 m. Ha).0109 million sq km in 1958.In Haryana as per 1966 estimate , area affected by water logging was (0.65 m.ha).0065 million sq km .In Uttar Pradesh , the estimated area was of the order of (0.81 m.ha.).0081 million sq km . In Rajasthan it was (0.35 m.ha.).0035 million sq km in 1968, while in Bihar and West Bengal large areas come under water logging due to flat nature of land and inundation by flood water . The Agriculture Commission (1976) estimated that out of the total water logged area of (6 million hectare).06 miilion sq km , (3.4 m.ha.).034 million sq km are subject to surface flooding , the remaining (2.6 m.ha.).026 million sq km have high water table. The problem of water logging has assumed a serious position mainly in irrigated areas of Haryana ,Punjab, Rajasthan and Uttar Pradesh.

The problem of water logging, although observed since 1965 in a number of surface water irrigated projects but no serious attempt was made to map the areas under water logging .The first reference of the mapping is of Nagraj et.al (1972)and later on by the Nat.Com. for Irrigation in (1976) which provided initial estimates of the aerial coverage of the water logging .Since 1976 , no systematic study was conducted and the last study was made by CGWB and the report published in 1999 (CGWB , 1999)to indicate the water logging problem and its status , district wise . The state wise water logging for the year 1998 during Nov(i.e.Post Monsoon Period)is given in Tabl1 . A photograph of the water logged area in part of Fazilka district Panjab is given as Fig 1 .

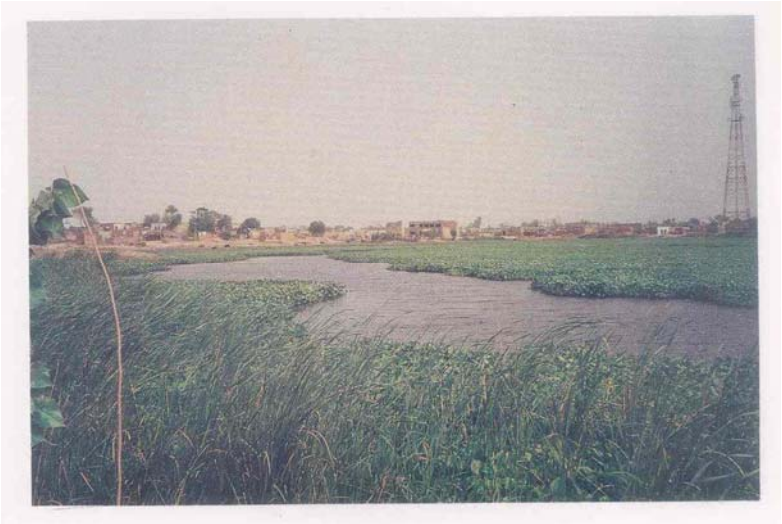

Figure 1 :Water Logged condition in part of Fazilka district,Punjab

Table 1 : STATUS OF WATER LOGGING AND GROUNDWATER SALINE AREAS IN DIFFERENT STATES

				November 1998		
Sl. No.	**District**	**Nagraj et.al. (1972)**	**Nat.Comm. for Irr. (1976)**	**Water logged Area (0-2m)**	**Areas prone To Water Logging (2-3m)**	**Area underlain by saline ground water**
		Sq.km	**Sq.km**	**Sq.km**	**Sq.km**	**Sq.km**
1	Andhra Pradesh	400	-	58300	61690	-
3	Assam	-	-	6475	9350	-
4	Bihar	3500	NR	28925	48000	-
5	Goa			278	392	24300
6	Gujarat	4840	NR	4330	5550	1362
7	Haryana	-	6200	5478	5455	11438
8	Himachal Pradesh			110	190	-
9	Jammu & Kashmir	100	-	504	566	-
10	Karnataka	-	-	15152	49683	8804
11	Kerala	-	-	3500	2800	-
12	Madhya Pradesh	NR	50	25666	16993	-
13	Maharashtra	1160	-	44250	91090	-
15	Meghalaya	-	-	950	950	-
18	Orissa	-	-	47492	28317	-
19	Punjab	14270	10900	4875	4500	3058
20	Rajasthan	NR	3480	2779	1680	141036
22	Tamil Nadu	-	-	30918	52640	3300
24	Uttar Pradesh	6900	8100	20566	59680	-
25	West Bengal	9090	18500	10298	64128	-
26	Delhi	100	-	-	-	140

A recent study was conducted in the Surat area in the catchment of Shampura-Delad –Jokha drain ,which is nearly 31.28 Km long with catchment area of 72.33 Sq. Km. This drain passes through the southern part of city and causes floods in the city area. During floods the runoff generated in the drain is estimated as 35.55 MCM. The impact is that the large area have become totally water logged . It thus indicates that it is only the irrigated command areas but also it is caused as a result of non utilization of ground water results in water logging.

Another other areas of concern relate to water logging in the delta areas of different rivers , as for example , in the Cauvery Delta , the depth to water level is 3m bgl and it covers about 77 sq km while the area with depth range of 3-5 m bgl cover about 874 sq km(CGWB,2002). The depth to water level of the three districts covering the delta area is given below, data pertains to 2001 and thus needs to be updated :

Table 2 : WATER LOGGING IN CAUVERY BASIN DELTA AREA

Tamil Nadu		November 1998		May 1999	
Sl.No.	**District**	**Water logged Area (0-2m)**	**Areas prone To Water Logging (2-3m)**	**Water logged Area (0-2m)**	**Areas prone To Water Logging (2-3m)**
		Sq.km	**Sq.km**	**Sq.km**	**Sq.km**
1	Thanjavur	3906	290	110	790
2	Nagapattinam	2689	0	660	860
3	Thiruvarur	1920	0	0	0

INLAND SALINITY - GROUND WATER SALINITY

Another outcome of the surface irrigation system is the increasing threat of soil/water salinity. National Commission on Agriculture 1976 estimated total affected area as 0.07 million sq km (7 million hectare) out of which 0.025 million sq km (2.5 million hectare) is under alkaline soils and 0.045 million square km (4.5 million hectare)under saline soils .

Subsequently , Ministry of Agriculture estimated that alkaline soil covers 0.0358 million sq km (3.58 million hectare) and the saline soil 0.055 million sq km (5.50 million hectare). It shows that the increase in the area of soil salinity and alkalinity over the years but since the last almost two decades no re-estimation has been made of the problem.

It has been estimated that over 1.93 lakh sq.km area in parts of Haryana, Punjab, Delhi , Rajasthan, Gujarat, Uttar Pradesh Karnataka, and Tamil Nadu is affected by salinity in ground water (EC>4000)micro-mhos, (Refer Table 1).

OVERVIEW OF CONJUNCTIVE USE STUDY

National Water Policy (1987) emphasized the need for Conjunctive Use of surface and groundwater in the Canal Command Areas and it should be insured that it becomes an essential part of the project right from the project planning stage itself .

In view of the seriousness of the problem and the importance of the conjunctive use, Govt. of India sanctioned six Conjunctive Use Schemes for detailed study in irrigation commands so that it can bring out up-to-date analysis and recommendations for application of conjunctive use to solve water logging problem and also increase in intensity of irrigation.Based on the encouraging results , four additional studies under Phase 2 covering Nagarjuna Sagar Project , Andhra Pradesh;IGNP –II,Rajasthan;Kossi Canal Command Area,Bihar and Gandhak Command Area , Bihar were sanctioned ,the final report is still awaited . An overview of 6 completed studies is given in Table 3. In order to de-water logged the area , the groundwater pumping has to increase , the groundwater development plan for the same is given below(Table 4) .

Table4: GROUND WATER DEVELOPMENT PLAN

S No	Area (Sq Km)	Water level to be lowered	Volume of Water (MCM)	No of Working Days	No of T/W Required
1	72.33	3m	17.3592	120	75
2	72.33	4m	23.1456	120	100

In case of Cauvery delta it was recommended to develop 19 MCM of groundwater by installing 147 tubewells

Table 3: OVERVIEW OF THE RESULTS OF CONJUNCTIVE USE STUDIES IN DIFFERENT IRRIGATION CANAL COMMAND AREAS

	Canal Name	**Total Area Under Study sq.km.**	**Water Logged Area sq. Km.**	**Conjunctive Use Planning**
1.	IGNP-1	5530	1150	Ground water development should be 18 per cent of canal water Released, the water logged areas will reduce to 785 sq.km. by 15th year; cost benefit ratio 1.03 .The present groundwater development is 7% of Canal releases with 100% cropping intensity ; cropping intensity increase to 120 % and groundwater development to 18%; the water logged area will reduce to 785 sq. Km.
2.	Hirakud	1570.18	Pre-monsoon-174 Post – Monsoon-1494	The present irrigation intensity is 170% but can be increased to 200 % by using surface water 90% and groundwater 10%.Cost benefit ratio is 1.66.
3	Sarada Sahayak	8978	4874	Under the conjunctive use plan, to control spreading of water logging it is proposed to reduce surface water utilisation from the present 1481.8 MCM to 1015.9 MCM and the ground water utilisation to be increased from 906.32 MCM to 1356.23 MCM;this will increase the cropping intensity from 153 % to 200%; cost benefit ratio 1.56 .
4	Tangabhadra	6354	Pre-monsoon-98.75 Post-Monsoon -229.00	The conjunctive use study indicates two possible scenarios or development plans. By implementing an integrated ground water development by these two plans 85.8% of the canal water shortage areas can be irrigated. The remaining 14.2%, adopting water saving methods; cropping intensity can be increased from 61.43 % to 116%. Cost benefit ratio 3.45.
5	Ghatprabha	10370	July- 143 Aug-344 Nov. - 580	The present cropping intensity which is 84% in left bank can be increase to 200% by utilising 84% of surface water and 16% of ground water. In the right bank cropping intensity of 140% by using 69% surface water and 31% ground water. Cost benefit ratio varies 1.25 to 5.34 for irrigated dry crops and oil seeds .
6	Mahi Kadana	3717	Pre-monsoon-33.70 Post-Monsoon -160.80	From the study it has been observed that out of 12 zones, in five zones already maximum possible irrigation intensity is achieved, in one zone, because of existing shallow water condition and saline groundwater, no further increases in irrigation has been considered. In the rest six zones spreading over are area of 33000 ha, only the irrigation intensity have to be maximized. It is proposed for an irrigation intensity of 185 % till 2015 with the water requirement of 2221 MCM from surface water and 792 MCM from ground water. The results of ground water simulation studies indicate that the present utilization of surface water and ground water in the proportion of 65:35 is optimal situation of conjunctive use , without creating anyadverse effect

CONCLUSION

In the developing scenario of food security and the impact of climate change vis-a-vis the water resources, it is now a necessity to deal with the problems of water logging and salinity in the Canal Command Areas more seriously. The outcome of the scientific study of the six completed conjunctive use studies, need to be considered for implementation .It is imperative that implementation of conjunctive use study and increasing the groundwater drop , will not only anti-water logged the area but will also recover the fertile land , increase the intensity of irrigation, water availability in the tail end and the distributaries. However , the conjunctive use of saline groundwater with surface canal water could not be carried forward because of the limitations but a better approach has to be worked out to deal with this increasing problem of salinity .

REFERENCES

1. Central Groundwater Board (1999),Bujhal News , Special Issue on Conjunctive –Use studies , Vol 14 No. 1& 2,pp 1-113.
2. Central Ground Water Board (), Water Logging and its Remedy by Conjunctive Use,Edited By Dr.D.K.Chadha ,Dr.S.P.Sinha Ray , Special Publication , pp1-141
3. CGWB(2002),Hydrogeological conditions in Cauvery Basins , Unpublished Report.
4. Coe,J.J.,"Conjunctive Use of Surface & Ground Waters –The California experience ",Seminar on Conjunctive Use of Surface and Ground Water Resources (1986),CGWB,pp2-1 to 2-42
5. Hall .W.A.,"A Economic Cost Factors for Conjunctive Use of Surface and Ground Water ",Seminar on Conjunctive Use of Surface and Ground Water Resources (1986),CGWB,pp7B-1 to 7B-6
6. Nagraj ,B.S.,Hoda ,M.Z., and Prasad R.K.,"An Appraisal of Water –logging Problems and Remedial Measures in Bihar ",Seminar on Water – logging –Problems & Remedial Measures ,Muzaffarpur ,Bihar.
7. National Commission on Agriculture ,Govt. of India ;Report volume 1 to XV,New Delhi ,1976.
8. Pyle,S.T., "Conjunctive Use Water Management Problems in Kern County ,California" ,Seminar on Conjunctive Use of Surface and Ground Water Resources(1986),CGWB , pp1A-1to 25
9. Sinha B.P.C,"Water – Logging in India –An overview .",Seminar on Conjunctive Use of Surface and Ground Water Resources(1986),CGWB,pp 4-1 to 4-11

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- South Asia Regional Water Vision (SASTAC) (San Diego ,USA, 28 April-4 May 2001) – Global Warming – Presentation of Indian Water Scenario - Unpublished
- UNESCO/IAEA/IAH Adelaide, Australia 12-22September2002- Technology Development in Artificial Recharge – Published
- US –EPA Program – 29 March - 5 April 1999 , visit in connection with the study of Ground Water Pollution and Regulatory Guidelines
- US- EPA Program – 1 April-9 April 2002
- Water Resources Management, Fluoride in Ground Water and Remediation Technology
- UNESCO/IAH. Wageningen Netherlands, 17-20 Dec. 2002, Climate variability and sub-surface storages – Examples from different countries – Published
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A driving force for promoting artificial recharge in the country & guided in preparing the First Master Plan on Artificial Recharge of India. Published more than 65 papers in National, International Journals & edited Central Ground Water Publications on Arsenic contamination in ground water, water logging & conjunctive use & Inland saline aquifers etc. Member of National Commission of “Integrated Water Resources Development Plan”, member of high level steering committee & of ownership of ground water constituted by planning commission. Has worked as technical expert for projects in Algeria, Mauritius, Nepal & Ethiopia & Has been the official delegate to Bonn (Germany) & Dhaka (Bangladesh).