TR-122

PERFORMANCE EVALUATION OF PERCOLATION TANKS

आपो हि ष्ठा मयोभुवः

NATIONAL INSTITUTE OF HYDROLOGY
JAL VIGYAN BHAWAN
ROORKEE-247667 (U.P.)
INDIA

1991-92

PREFACE

Percolation ponds are constructed across natural water courses, gullies, drainage points of watersheds to impound the run off water and retain it for a longer time with the objective of affecting percolation in the subsurface both laterally and vertically. These also prevent flash floods and act as silt catching units and prevent silting up of high costing reservoirs and directly irrigating tanks located down below. The percolation ponds thus serve as very effective means of not only recharging groundwater but also as a very good soil and water conservation structure. Soil moisture regime is also improved in the zone of influence. In some cases, the pecolation ponds are helpful to alleviate the drinking water problem by recharging the nearby drinking water wells. The scope for installation of large, medium and minor irrigation projects are limited by the availability of site and funds in hilly and plateau areas. The scope for installation of run off water harvesting "small reservoirs" or water storage sturctures/ponds have a large potential which need to be tapped judiciously for making the soil and water conservation programs and community irrigation programs more attractive and acceptable to the rural community and that too to the farmers.

Perfolation ponds have special significance in agricultural and rural economy. It is quick to establish, cost effective and employment generative besides the soil and water conservation benefits. On the other side, it is easy to maintain by promoting community efforts. They are generally small, but the possibility to build many such percolation ponds in rural side brings about a sense of satisfaction among rural settlements that they are being cared for. Thus, percolation ponds could also be a tool for promoting socio-political amity in concurrence with development. Having accepted the development of percolation ponds as a strategy in dry farming improvement technique and having implemented thousands of such schemes throughout the country, it is high time an evaluation of the efforts in terms of the financial, economic and socio-political aspects of these structures need to be studied. This report discusses about planning, design, construction, maintenance, socio-economic aspects of constructing percolation ponds. Report also discusses about the monitoring and performance evaluation of the percolation ponds.

The study has been carried out by Mr. Sudhir Kumar Goyal, Scientist 'B', Drought Studies Division. The manuscript have been typed by Mrs. Mahima Gupta, Stenographer and Sh.Rajneesh Kumar Goel, L.D.C.

Satish Chandra
(Satish Chandra)

CONTENTS

ABSTRACT

Percolation ponds are small water harvesting structures constructed across small natural streams and water courses to collect and impound the surface runoff during monsoons so as to facilitate the impounded water to infiltrate into the land and percolate through the substrata thereby recharging the groundwater reservoir. Construction of percolation ponds conserves the runoff and conveys it to the groundwater reservoir steadily. The yield of wells at the downstream side of the pond increases significantly. The zone of influence depends upon the slope of waterspread area of the pond. After the construction of pond, the yield of water increases phenomenally for every unit of rainfall. Permeability of the soil is primarily responsible for the rate of groundwater recharge from the pond. Recuperation of water in the well after construction of pond is rapid besides increase in quantum. This is aided by the depth of storage in the pond. The pond helps harnessing the runoff efficiently through proper management. The pond exerts a cooling affect on the climate and this microclimate results in economy in water use by crops in the zone.

The percolation ponds are designed and constructed with the presently available hydrologic guidelines and norms. These ponds are serving well in the artificial recharge of the ground water reservoir and the benefit of these structures have been well appreciated by the farming community of well commands. However there is a scope for further refinement in the hydrologic norms and guidelines for the design and construction of percolation ponds.

The present study discusses about planning, design, construction, maintenance, socio-economic aspects of constructing percolation ponds. The report also discusses about the monitoring and performance evaluation of the percolation ponds.

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

The percolation ponds in its true meaning may be defined as a surface water body located on as percolating media. These surface water bodies are created by obstructing the surface runoff from a catchment. The water impounded in the tank by such structures continuously goes on recharging the aquifer lying below, which gets depleted in due course of time by the use of ground water in the immediate vicinity. The percolation tanks which have been taken up as scarcity measures and primarily designed with the engineering aspects may vary largely in their degree of benefits from one site to the other. There is no doubt about the utility of such structures like percolation ponds which are bound to control the runoff and would help in providing as additional recharge to the aquifer to provide continuity in the watertable in the post monsoon period even though its techno-economic viability may not be established in certain cases. After considering the alarming conditions in drought prone areas, the utility in whatever little manner it has, even in alleviating the drinking water problem would be of immense relief to the population in these areas.

1.1 History of Percolation Ponds

The idea of construction of percolation ponds is not new to India and it dates back to many centuries. Our forefathers had clear ideas about the engineering and scientific aspects of these types of water harvesting structures.

During the period of Ashoka the Great, a lot of shady trees were planted on both the sides of roads and constructed so many ponds. This is well known to all of us from history. From this it is very clear that Ashoka the Great, had clear and definite knowledge about ecological balance and percolation. The ponds constructed by Ashoka and subsequently by others not only served the purpose of drinking water for travellers and cattle but also helped in recharging the groundwater of the surrounding area.

1.2 Scope of the study

Percolation ponds are constructed across the small natural streams, nallahs, gullies and drainage points of watersheds to impound the runoff water for various water requirements and also to recharge subsurface by percolation. These percolation ponds prevent flash floods to some extent and act as silt catching units and prevent silting up of high costing reservoirs. The percolation ponds serve as very effective means of not only recharging aquifer but also as a very good soil and water conservation structure. These percolation ponds are constructed during scarcity periods for giving relief through employment to the agricultural as well as other labourers, by using locally available materials. The percolation ponds are helpful to alleviate the drinking water problem by recharging the nearby drinking water wells. The scope for installation of large, medium and minor irrigation projects are limited by the availability of suitable site and funds in the hilly and plateau areas. The scope for installation of runoff water harvesting "small reservoirs" on water storage structures/ponds have a large potential which need to be tapped judiciously for making the soil and water conservation programmes and community irrigation programs, more effective and acceptable to the rural community and that too to the farmers (Ram Babu, 1986).

As discussed earlier, the need for recharge of groundwater to sustain the present level of its utilization has been well recognized and large investment is made on construction of percolation ponds. In this context, it is not essential to evaluate the actual benefits derived from the ponds in depth to justify the investment on the project. A systematic examination, of the effect of rainfall on the extent of water level, the reflection of percolation on the yield of wells in the vicinity of the pond, area irrigated etc. is required after the construction of a percolation pond.

1.3 Classification of Percolation Ponds

Ponds are nothing but small storage reservoirs to store water at the time of monsoon to utilize the same for various water requirements. Depending on the site/place and requirement these ponds can be classified as following :

i) Ponds to check floods

ii) to check silts to reach to large reservoirs

iii) to store water for drinking and irrigation purposes

iv) for artificial recharge of aquifers

v) for recreation and tourist purposes

vi) village and temple ponds

2.0 SOIL SUITABILITY

Following points must be considered while analysing the soil suitability for the pond :

i) The top soil at the pond site should be pervious to provide good seepage.

ii) Pond should not be constructed in the areas within black cotton soil and similar impervious soils.

iii) There should be good storage space underground so that there is scope for storing large quantity of groundwater underneath within the formation.

iv) There should be appreciable weathered thickness with good porosity atleast for about 10 to 15 metres below ground level.

v) The depth to bed rock level should be atleast 15 metres below ground level.

vi) The location of the pond should be such that the depth of ground water level prior to rainfall should be atleast 5 metres below ground level before the formation of the pond, so that there is a storage space to receive the recharge from the pond.

It is assumed that percolation takes place due to permeability of the soil by gravity and that it obeys the ordinary laws of hydraulics. If it is so, it need not necessarily be in the lower reaches of the pond. The percolation effect may be on all sides. From the studies conducted in Tamilnadu, Andhra Pradesh & Karnataka it is evident that :

i) Percolation from the pond can be in all the directions

ii) The percolation effect often depends upon the distance of the pumping source from the pond and the rate of pumping.

The following points should be noted while deciding percolation effect which depends upon permeability of the soil :

1. The permeability of any soil for water or air is a function of the amount and size distribution of the pores.

2. The size, density and hydration of the soil particles have great effect on permeability.

3. The permeability of the soil depends upon the clay percentage dispersion coefficient and dry bulk density.

4. The textural differences have little influence on permeability, at very high apparent densities for soils finer than sandy loams.

5. The permeability of clays even in clayey soils increases as hydration of the particle decreases.

6. The permeability of a soil is directly related to its non capillary capacity.

Some of the conclusions drawn from the studies are :

a) In two soils with the same percentage of porespace one may readily allow water to drain away and the other may be highly impervious to water movements. In other words the total porosity is not very important for classifying the soil on structural basis.

b) A clear distinction will have to be made between two types of porosities of the soils with the same percentage of pore space. By this it is meant that one has to be classified as soil with capillary porosity and the other as non-capillary porosity.

c) The non capillary porosity is the sum of the volumes of the large pores which do not hold water tightly by capillarity. The large pores are normally filled with air and are responsible for air capacity and ready percolation of water capacity of soils.

d) The small pores that hold water by capillary are responsible for water capacity of soils.

e) The more the soils aggregated into compound particles or crumbles, the greater will be the percolation of non-capillary pore space, and more will be the percolation.

From the above it is evident that the permeability is directly proportional to the non-capillary pore space available in the soil, and percolation is directly proportional to the permeability of the soil.

3.0 GUIDELINES FOR PLANNING

In our country we are trying hard to utilize almost all the surface water resources, by creating surface storages in respect of dams and surface storage ponds and tanks. These ponds and tanks serves the purpose of storage as well as a means of recharge of groundwater.

Some of the points which may be controversial, should be taken into account carefully while planning for a percolation pond.

i) Extra money will be spent in lifting the ground water from wells which are recharged by the percolation of surface water stored in the percolation ponds.

ii) Only 30 to 50% of surface water stored in the percolation ponds will percolate to augment the groundwater, however, a large amount of water will be lost through evaporation which cannot be avoided.

iii) It is doubtful whether all the recharged water available is fully utilized from wells within the zone of influence which itself is not well defined till today and is based on many geological and topological parameters.

Anyhow even in the light of the above points the percolation ponds are useful in mobilizing additional water resources during excessive rainfall years, which otherwise would be waste. But there is a general feeling that the formation of the ponds results in shifting the benefit from downstream area to upstream area at extra cost, which is detriment to the lower down riparian rights. So engineers, scientists and planners of the government and non government organisations should think of re-examining the entire policy.

A number of studies have been carried out to arrive at a definite conclusion regarding the quantitative benefits reaped out of the ponds. As the study is very complex and based on many varying parameters, no conclusion could be drawn from the studies. However, certain guidelines to be adopted as a policy in forming the ponds are given by various study groups. In short they are :

i) Ponds should be formed only in non-system area where a regular irrigation system is not available.

ii) Ponds should be constructed across small streams which have not yet been fully tapped.

iii) Preference should be given to locations where tanks and diversion works could not be formed, because gravity irrigation is preferable to lift irrigation.

iv) Areas where there is soil erosion and flash floods occur frequently should be prefered.

Before planning to construct a percolation pond the purpose of percolation tank should be clear. While locating a site for construction of percolation tank the following parameters should be considered :

- Hydrological
- Geological
- Topographical
- Terrain
- Sociological
- Economical

However the following points in general may be kept in mind:

i) Before selecting a site one should be considerate to geological formation below percolation tank.

ii) Avoid interference of zone of influence of two percolation tanks. Pond density will be dependent to hydrometeorological conditions of the area i.e. availability of quantum of water without affecting the efficiency of one another.

iii) Area of catchment should be high enough to store ample quantity of water during monsoon so that enough recharge may take place.

iv) Benefits of installing a percolation tank should be well evaluated keeping in view the losses like evaporation and seepage. Benefit cost ratio should be considered carefully i.e. Socially Benefit cost ratio (SBC) should be adopted. Also in case of water scarce area, B.C. ratio should not be the criteria for installation of a percolation tank.

v) Number of observation wells should be adequate to ensure the proper monitoring of the recharge enhanced by seepage.

vi) The formation of pond may preferably be taken up in areas, where the formation will not adversely affect the water use in the downstream area.

vii) The scheme should be a multipurpose one however priorities may be fixed among :

a) groundwater recharge
b) soil conservation
c) flood control etc.

viii) The pond should as far as possible be formed in available government poramboke, so as to avoide land aquisition and reduction of cultivable area. This helps in bringing down the cost of the scheme.

ix) Submersion of cultivable lands should as far as possible be avoided or kept at minimum.

x) Adequate and suitable materials for formation must be available at the site itself or in the vicinity.

xi) It will be beneficial for having percolation ponds upstream of the reservoir so that silting in the reservoir is reduced.

4.0 DESIGN, CONSTRUCTION & MAINTENANCE

The design of the percolation ponds is mainly based on the hydrology of the stream where the pond is to be located and as well as the hydrology of the percolation pond itself. Therefore the hydrology can be discussed separately viz.

(a) Hydrology of the stream or surface water to be received and

(b) Hydrology of the water stored in the Percolation Pond.

Now a days the percolation ponds are being constructed as micro level earthfill dams using masonry or other local materials. Some of the parameters required in defining the hydrology of the stream are as follows :

4.1 Estimation of yield

One of the important applications of hydrology in the design of percolation ponds is the estimation of annual water yield from the catchment of percolation pond to decide the storage capacity of the pond. The vital factors governing the yield from catchments are the rainfall pattern and the catchment characteristics. The rainfall data available from the nearest representative raingauge station are utilized for the assessment of yield in the absence of rainfall data for the specific watershed. The nature of the catchment is decided by collecting data on hydrological characteristics, namely, orientation, slope, vegetation and other surface and subsurface conditions and is classified either as good or average or bad from the point of surface runoff potential.

The annual yield of the catchment is assessed by making use of Strange's table of Runoff for the known data on the total monsoon rainfall and the nature of the catchments. However, yield of a catchment can also be determined by other methods which may be more accurate but for the practical field purpose the Strange's table serves the purpose. The Table-1 shows the Strange's table.

4.2 Estimation of Design Flood

Another important aspect involved in the design of percolation ponds is the determination of the waste-weir capacity which is to be derived by the estimation of design flood. The capacity of the ponds are generally of the order of 0.0071 M.cu.m. (0.25 m.cft) to 0.0283 M.cu.m. (1.00 m.cft). The capacity may be more or less, based on the requirements of water which in turn depends upon the ayacut. Design flood is estimated by using conventional formulae (like Ryve's Formula or Dicken's Formula) intended for small watershed in addition to local enquiries and observations of flood marks in the natural drainage system. As the catchment of percolation ponds are very small, that is less than 8 sq.km. the popular Rational formula is mostly used. The well known Rational formula is :

$$Q = CIA$$

where Q = Design Flood

I = Intensity of Rainfall of desired frequency having a duration equal to or more than the time of concentration of the watershed.

A = Area of catchment

& C = Coefficient depending upon the nature of catchment.

The values of 'C' for different classifications of catchments are given in Table-2.

TABLE OF TOTAL MONSOON RAINFALL AND ESTIMATED RUN-OFF AND YIELD PER SQUARE MILE FROM CATCHMENT AREAS

STRANGE'S TABLE

Total monsoon rain fall in inches.	Good catchment			Average catchment			Bad catchment		
	Percentage of run-off to rainfall	Depth of run-off due to rainfall in inches	Yield of run-off from catchment per sq. mile in mcft.	Percentage of run-off to rainfall	Depth of run-off due to rainfall inches.	Yield of run-off from catchment per sq. mile in mcft.	Percentage of run-off to rainfall.	Depth of run-off due to rainfall inches.	Yield of run-off from catchment per sq. mile in mcft.
1.	0.1	0.001	0.002	0.1	0.001	0.001	0.05	0.005	0.001
2.	0.2	0.002	0.009	0.15	0.003	0.006	0.1	0.002	0.004
3.	0.4	0.012	0.029	0.3	0.009	0.021	0.2	0.006	0.014
4.	0.7	0.028	0.065	0.5	0.021	0.048	0.3	0.014	0.032
5.	1.0	0.050	0.116	0.7	0.037	0.097	0.5	0.025	0.058
6.	1.5	0.090	0.209	1.1	0.067	0.156	0.7	0.045	0.104
7.	2.1	0.147	0.341	1.5	0.110	0.255	1.0	0.073	0.170
8.	2.8	0.224	0.520	2.1	0.168	0.390	1.4	0.112	0.260
9.	3.5	0.315	0.732	2.6	0.236	0.549	1.7	0.157	0.366
10.	4.3	0.480	0.999	3.2	0.322	0.749	2.1	0.215	0.499
11.	5.2	0.572	1.329	3.9	0.429	0.996	2.5	0.286	0.666
12.	6.2	0.744	1.728	4.6	0.550	1.296	3.1	0.372	0.864
13.	7.2	0.936	2.174	5.4	0.702	1.630	3.6	0.468	1.087
14.	8.3	1.162	2.699	6.2	0.871	2.024	4.1	0.581	1.349
15.	9.4	1.410	3.275	7.0	1.057	2.457	4.7	0.705	1.638
16.	10.5	1.680	3.903	7.8	1.260	2.927	5.2	0.840	1.951
17.	11.6	1.972	4.581	8.7	1.479	3.435	5.8	0.986	2.290
18.	12.8	2.304	5.353	9.6	1.728	4.014	6.4	1.152	2.676
19.	13.9	2.641	6.135	10.4	1.900	4.601	6.9	1.320	3.067
20.	15.0	3.000	6.970	11.25	2.250	5.227	7.5	1.500	3.485
21.	16.1	3.381	7.855	12.0	2.535	5.891	8.0	1.690	3.927
22.	17.3	3.806	8.842	12.9	2.856	6.631	8.6	1.903	4.421
23.	18.4	4.232	9.832	13.8	3.174	7.374	9.2	2.116	4.916
24.	19.5	4.680	10.872	14.6	3.510	8.154	9.7	2.340	5.436
25.	20.6	5.150	11.964	15.4	3.862	8.973	10.3	2.575	5.982
26.	21.8	5.668	13.168	16.3	4.251	9.876	10.9	2.834	6.584
27.	22.9	6.183	14.364	17.1	4.637	10.773	11.4	3.091	7.180
28.	24.0	6.720	15.612	18.0	5.040	11.709	12.0	3.360	7.806
29.	25.1	7.279	16.911	18.8	5.459	12.683	12.5	3.639	8.455
30.	26.3	7.890	18.330	19.7	5.917	13.747	13.1	3.945	9.165
31.	27.4	8.494	19.733	20.5	6.370	14.799	13.7	4.347	9.066
32.	28.5	9.120	21.188	21.3	6.840	15.891	14.2	4.560	10.594
33.	29.6	9.768	22.693	22.2	7.326	17.019	14.8	4.884	11.346
34.	30.8	10.472	24.329	23.1	7.854	18.246	15.4	5.236	12.164
35.	31.9	11.165	25.939	23.9	8.373	19.454	15.9	5.582	12.969
36.	33.0	11.880	27.600	24.7	8.910	20.700	16.5	5.940	13.800
37.	34.1	12.617	29.312	25.5	9.462	21.984	17.0	6.300	14.656
38.	35.3	13.414	31.163	26.4	10.060	23.372	17.6	6.707	15.581
39.	36.4	14.196	32.980	27.3	10.647	24.735	18.2	7.098	16.490
40.	37.5	15.000	34.848	28.1	11.250	26.136	18.7	7.500	17.424
41.	38.6	15.826	36.767	28.6	11.869	27.575	19.3	7.913	18.383
42.	39.8	16.716	38.835	29.8	12.537	29.126	19.9	8.358	19.417
43.	40.9	17.587	40.858	30.6	13.190	30.643	20.4	8.793	20.429
44.	42.0	18.480	42.933	31.5	13.860	32.199	21.0	9.240	21.466
45.	43.1	19.395	45.058	32.3	14.546	33.793	21.5	9.697	22.529
46.	44.3	20.378	47.342	33.2	15.283	35.506	22.1	10.189	23.671
47.	45.4	21.338	49.572	34.0	16.003	31.179	22.7	10.669	24.786
48.	46.5	22.320	51.854	34.8	17.740	38.890	23.2	11.160	25.927
49.	47.6	23.324	54.186	35.7	18.493	40.639	23.8	11.662	27.093
50.	48.8	24.400	56.686	36.6	18.300	42.514	24.4	12.200	28.343
51.	49.9	25.449	59.123	37.4	19.086	44.342	24.9	12.726	29.561
52.	51.0	26.520	61.611	38.2	19.800	46.200	25.5	13.260	30.805
53.	52.1	27.713	64.151	39.0	20.709	48.113	26.0	13.806	32.075
54.	53.3	28.782	66.866	39.9	21.506	50.149	26.6	14.391	33.433
55.	54.4	29.920	69.510	40.8	22.440	52.132	27.2	14.960	34.755
56.	55.5	31.080	72.205	41.6	23.310	54.550	27.7	15.540	36.102
57.	56.6	32.262	74.951	42.4	24.196	56.213	28.3	16.131	37.475
58.	57.8	33.524	77.883	43.3	25.163	58.412	28.9	16.762	38.941
59.	58.9	34.751	80.734	44.4	26.063	60.550	29.4	17.375	40.367
60.	60.0	36.000	83.635	45.0	27.000	62.726	30.0	18.000	41.817

Table 2 : Value of Coefficient 'C' in Rational Formula Q = CIA.

Nature of Catchment	Value of 'C' in Rational Formula
Good	1.0
Average	0.72
Bad	0.45

4.3 Number of Fillings

The present practice is to adopt 3 fillings for the percolation ponds for 2 crops, irrespective of the area where the pond is formed. Assuming 3 fillings can hold good only in the case of Irrigation tanks, as the depletion of storage is rapid, which allows for simultaneous filling by flood water. Therefore the tanks are formed by assuming 2 fillings for single crop and 3 fillings for double crop. But the duty for Irrigation tanks are adopted as 71.5 to 114.4 hectares/M.Cu.m. for wet cultivation. But the assumption of 3 fillings in the case of percolation ponds, irrespective of the area may not hold good, since the depletion of the pond is dependent on the rate of percolation, climatic conditions etc. In the case of some percolation ponds practically even 2 fillings will be impossible, where there are no rains in summer and precarious rains in rainy season. But it is to be presumed that the assumption of 3 fillings is being adopted to bring down the capacity of the pond which consequently results in economy in forming the pond.

Even with the above assumption, some of the ponds which actually do not get 3 fillings are able to cope up to the requirement of the crops through the wells. The reason is that the increased duty adopted as 357.5 Hect/M.Cu.M. (as against 71.5 to 114.4 Hect/M.Cu.M in the case of tanks) is able to take care of the II crop under the pond.

It is therefore advisable to provide percolation ponds with larger capacity in areas where there are no rains in summer and with precarious rains in rainy season. The No. of fillings in such cases should be restricted to the yield available.

On the other hand the present assumption upto 3 fillings may be followed in areas where the rainfall is fairly good or reasonable in both the monsoon periods. Hence the number of fillings to be assumed should be based on the quantum and period of rainfall, dependable yield for the area etc.

4.4 Zone of Influence :

The zone of influence of percolation pond is the area over which the percolation of the impounded water of the pond takes place thereby recharging the acquifer and improving the ground water storage. As a rough practical guide for the assessment of the zone of influence of a percolation pond, the area encompassed by the sector of a circle of radius of 915 M and the pond at the downstream side of the pond is taken as the zone of influence of the pond. However more accurate delineation of the zone of influence of percolation pond can be done only if detailed information on the nature of the formation of the sub strata, its hydrogeology, ground water table etc. are available. The Centre for Water Resources of Anna University, Madras has recently conducted some field studies on the recharging effect of percolation ponds in Dharmapuri and Salem districts and has come out with findings that the zone of influence extends upto a distance of 1.65 to 2.8 KM at the downstream side of the pond. These findings are location specific. Further refinement in the delineation of zone of influence of ponds in various regions of the country is possible only if micro level survey on the hydrogeology of the land is undertaken and all the required data regarding the nature of formation and the ground water hydraulic gradient of the acquifer are made available. However a rough estimate of the zone of influence by visual observation of water level in wells for the recharge of the acquifer in the adjoining area is quite adequate for the construction of percolation ponds.

5.0 SOCIO-ECONOMIC ASPECTS

Socio-economic, cultural and political constraints and opportunities play a crucial role in determining the nature of management of percolation ponds. On analysing the pros and cons of traditional systems of water/irrigation structures management in India, a combination of ecosystem management in conjunction with traditional practices, such as repair and maintenance of the tank by the community and community management, has been suggested in this chapter.

The building of percolation ponds has been an age old practice. This has now become an important system of enhancing irrigation potential because this checks surface runoff to go in waste by recharging the underground water which is being used enormously to irrigate farming areas. At the same time, there can be problems if these percolation ponds are not managed properly. The management involves three groups which are i) the government ii) the community iii) the well owners for whom percolation ponds are a special resource in terms of recharge. All the issues related to social, cultural and political factors at all levels are to be handled carefully otherwise the goal, of construction of percolation ponds, of providing an appropriate micro climate for agriculture and sound ecological balance without large scale disturbances will not be fulfilled. The various points which needs thorough investigation in the context of socio-economic aspects of construction of a percolation are as follows :

i) Technical management aspect
ii) Social management aspect
iii) Social conflicts
iv) Maintenance issues
v) Socio-cultural and political factors

5.1 Technical Management Aspect:

The direct effect of percolation ponds is the recharging of groundwater aquifers so that there is enough water for irrigation to the crops from wells surrounding the ponds resulting in assured supply of water during times of need. The indirect effect of percolation ponds has reduced risk of crop failure and higher production due to assured supply of water from groundwater aquifer. It is experienced that rainfed crops may fail but crops irrigated from groundwater usually yields well, even if the groundwater table falls because of excessive withdrawals. Percolation ponds therefore could increase the potential of groundwater yield through recharging the groundwater, which works as a cushion or buffer in the years of scarcity. Additionally, the ponds could be an ecosystem, providing a microclimate for agriculture and thus playing a role in the ecology of the surrounding area.

5.2 Social Management Aspect

The researches/projects carried out by various organisations in the states of Maharashtra, Gujarat, Andhra Pradesh, Karnataka, Tamilnadu indicated that Water Users Association and Community Participation through a formal organisation specially established, can be effective in rehabilitation and maintenance of the tanks. Conversely, a combination of all these managerial practices, after a careful analysis of their feasibilities, can be worked out. But what emerges as the most plausible means of management of percolation ponds would depend on local conditions and perceptions and, above all, a willingness on the part of the locals to partake in the pond management.

5.3 Social Conflicts :

It has been experienced that in the large scale irrigation systems, the three important managers, the government, the community and the individual are powerful in the village. In some cases, the individuals are inclusive of all those who is benefited from such systems. This could be true in the case of percolation ponds as well. But, to stress one pertinent point, the percolation ponds could not be treated as a centrally controlled resource patch. Decentralization of management is a definitive means by which percolation ponds could be managed. This means that there cannot be explicit roles for the government, for community becomes predominant with individuals having a say in the day to day maintenance of the resource patch.

This community management can indeed lead to conflicts, especially in sharing responsibilities of management and taking the advantage of the function of percolation ponds, that is, recharging. A socially and politically influential individual can take undue advantage of his position and thus lead to conflicts in resources (land-water ecosystem) sharing by the community. However, the ponds are not the direct sources of irrigation and as such the conflicts can be made minimal. Conflicts, otherwise, might arise, nevertheless in the difference of opinion that might surface in the community managerial strategies worked out on mutual consultation.

5.4 Maintenance Issues :

If Government acts as the resource manager, it should do so only by formal organisation, commissioned for the purpose of maintenance and sustained use of the percolation ponds, for that is the way most governments act. The responsibilities are therefore given to this organisation, say, the Department of Agriculture/Irrigation and the day-to-day operations therefore become routine operations offered in the official manuals. These governmental organisations should undertake necessary steps for the maintenance of Percolation ponds on long term basis. The recurring activity in this context would be desilting operation and care in retaining the infiltration levels. Geologists and engineers of these organisations can take care of such responsibilities without much difficulty.

On the other hand, if community and individuals of the community take the responsibility of maintenance of percolation ponds, the option falls on the known features of the traditional management practices found in many villages. The community management, with individual participation built in on a community and informal basis, could provide several benefits to its members, namely, reliable maintenance, minimum conflicts and better organisation and maintenance of percolation ponds and other resources on the basis of mutual respect for rights. The success of community organisation is assured only when the government recognizes, and assists, the organisations at community level. It should be recognized by the government that decentralization of water management is an important prerequisite for a smooth working of the community management organisation.

5.5 Social-Cultural and Political Factors:

Social relations and cultural bondages are very important in the management of percolation ponds for a variety of reasons, the most important being decentralization of controls and unification of purposes in respect of percolation ponds. However, for the participants in the management of percolation ponds, professional roles on a mutual reciprocal basis may be identified. The new roles include such activities as : providing information about maintenance of percolation ponds - a working manual is a must, elucidating the processes which give rise to malfunctioning in particular kinds of environmental (erosion, sedimentation for example) and socio-economic circumstances (conflicts in communities jeopardizing collective management effects, for example), helping to assess priorities for improved distribution of water by infiltration and monitoring and evaluation of trends in community management.

To put these points in context, there is a need to remember that social fabric in a village community is never as objective as it may appear. Therefore, to make community management work really well, there is a need of cooperation and interaction among scientists (Geologists and Water Resources Engineers), governmental organisations (Central or State) and community (management organisations like Water Users Associations etc.).

6.0 APPRAISAL & EVALUATION

Percolation ponds have special significance in agricultural and rural economy. The percolation ponds have employment generation beside the soil and water conservation benefits. The maintenance of percolation ponds can be easily done by community involvement thus making them cost-effective. Percolation ponds are generally small, but the possibility to build these structures in rural areas brings a sense of satisfaction and security among the rural masses that they are being cared for. Thus, percolation ponds could also be a tool for promoting socio-political amity in concurrence with development. Having accepted the development of percolation ponds as a strategy in dry farming improvement techniques and having implemented thousands of such schemes throughout the country, it has become necessary to evaluate the financial, economical and socio-political aspects of these structures.

6.1 Methods of Evaluation

Percolation ponds are small (in terms of size and investment) structures but numerous in number and community based (assets). This basic aspect of these schemes neceesitates the need to evolve appropriate monitoring and evaluation systems that could be put to use by the community itself or by the grass root functionaries at village level.

There are two crucial information requirements in the monitoring and evaluation of percolation ponds.

a) Recharge assessment
b) zone of influence

Some of the evaluation methods which can be used are :

6.1.1 Mass Balance Method :

This method is adopted by using groundwater level fluctuations which is a function of rainfall runoff, recharge from percolation ponds and irrigation return flow recharge. This method is not simple for adoption by the lower level functionaries. The reason for this are:

a) Many of the catchment areas may not have dependable rainfall data.

b) Calculation of rainfall percolation and irrigation return flows are too technical to be followed by the field people.

c) Need for a time series data. Despite having worked out the recharge rate, further attempts are needed to identify and demarcate the zone of influence.

6.1.2 Observation & Control Wells :

This method is adopted to study the 'recharge impact' of the percolation ponds. The wells upstream to the percolation ponds are called control wells and wells downstream are called experimental or observation wells.

Though this method is relatively less complicated. Yet there are few points to study carefully.

a) rationale for the assumption that upstream wells may not be benefitted from percolation ponds thereby marking them as control wells.

b) method of determination of zone of influence through this method.

Besides the functional analysis carried out, this method requires time series data on rainfall and therefore faces some of the constraints applicable to mass balance method.

6.1.3 Dye or Isotope Method

Use of chemical dye (Rhodomine) or some isotope in the percolation ponds and collecting water samples from wells in the upstream as well downstream areas of percolation ponds is called Dye or Isotopes method utilized to determine zone of influence. Requirement of manpower to collect the samples makes this method uneconomical.

If this method is found to be inexpensive, it is very useful and effective as far as accuracy and practicability is concerned. This could be made mandatory for all percolation ponds. Seasonal and annual effects could easily be ascertained by repetition of this exercise.

6.1.4 Rapid appraisal : An easy and cost-effective alternative :

This method involves a quick reconnaissance in the study area and ascertaining from farmers both in upstream and downstream on changes in water levels in their wells after the construction of percolation ponds. This could be easily achieved through the field staff placed in rural areas. This would give a fairly accurate idea about the "zone of influence".

Operationalisation of this concept can be as follows. The estimated zone of influence can be ascertained from official records of the construction of percolation ponds. The first stage of rapid appraisal may begin in a smaller area than estimated and proceed further outwards, if found necessary, as explained in Figure 1.

This rapid Appraisal approach can also be adopted to ascertain the expanded area under irrigation, additional wells, that have come up after percolation ponds, changes in cropping pattern (or reasons for no change), seasonal fluctuation, suggestion for betterment etc.

Rapid Appraisal technique is more a qualitative method where quantitative statistical information is only secondary. The information may not stand statistical scrutiny, but the guiding principle here is the one enunciated by Chambers (1989).

Optimal ignorance	:	Knowing what is not worth knowing
Appropriate inprecision	:	Much data collected has a degree of accuracy which is unnecessary.

Here, the emphasis is on ascertaining the indication of changes and impact. It can be a starting point for in-depth and detailed investigations.

6.2 Methodological Considerations for Performance Evaluation

The following methods and factors are suggested for effective monitoring and evaluation of percolation ponds.

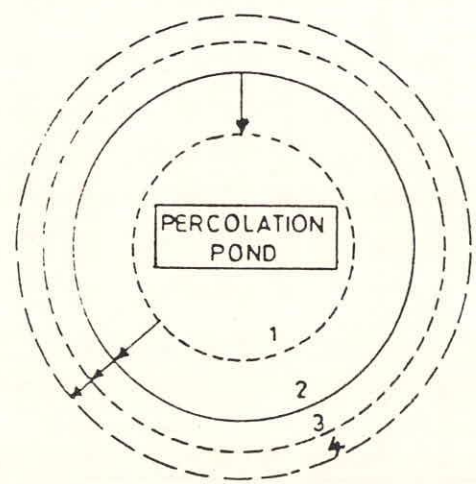
6.2.1 Impact Assessment

6.2.1.1 Measurement of Change :

1. a) Wells (observation) within the zone of influence.

   b) Wells (control) outside the zone of influence

FIG 1. ZONE OF INFLUENCE ASSESSMENT THROUGH RAPID APPRAISAL



______________ Estimated zone of influence at construction

-------------- Area for rapid appraisal in stages

2. Position before and after percolation ponds with area irrigated and cropping intensity as proxy indicators.

6.2.1.2 Sustainable benefits :

Repeat surveys at periodic intervals to monitor changes in the long run. This will also provide information on,

a) assessment of sedimentation

b) maintenance schedule

c) No. of wells

6.2.1.3 Water recharge benefits:

Irrigation wells (factors)

a) area irrigated

b) type and efficiency of water lift (mechanical/animal drawn) (HP)

c) drinking water wells

6.2.2 Economic Evaluation of Percolation Ponds :

Besides all the above listed points, items that need to be included are :

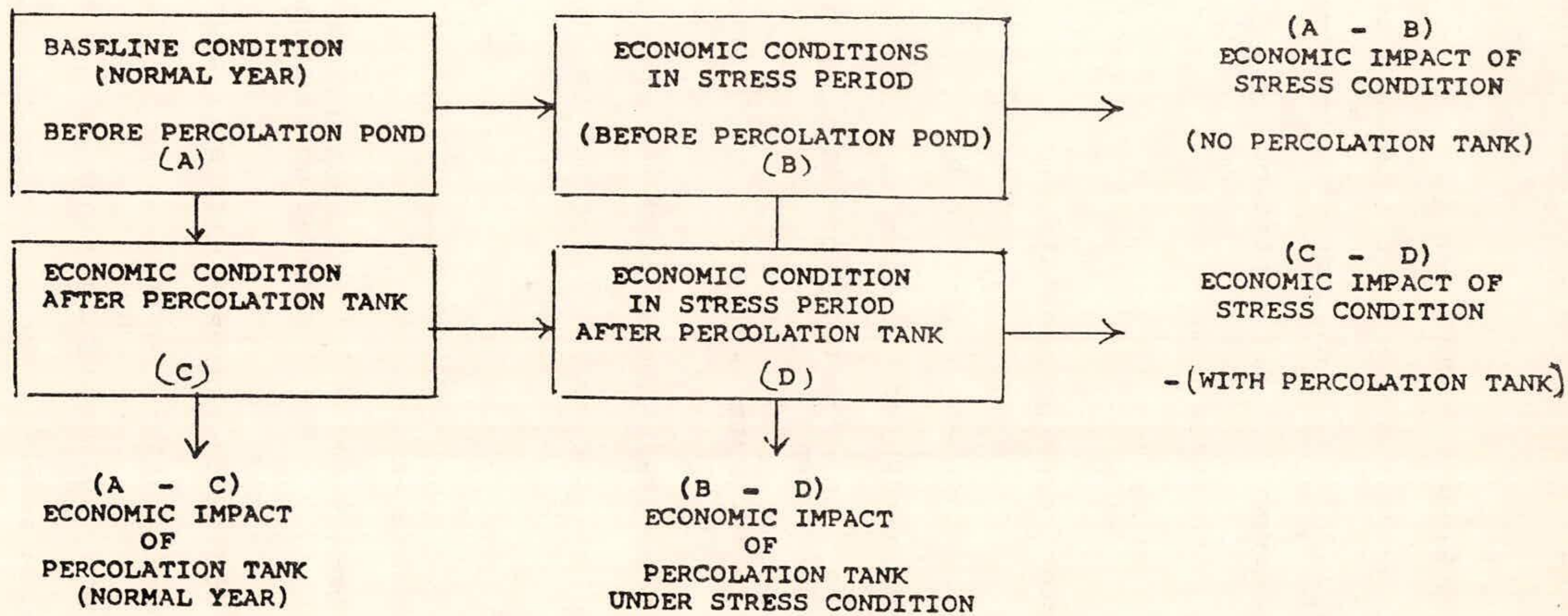
1. Benefits due to reduction in soil erosion/soil conservation

2. Employment - in the construction of ponds
   - increased employment in cultivation

Klien and Kulshreshtha (1983) have evolved an Agricultural Drought Impact Evaluation Model (ADIEM) as a framework for drought impact and drought mitigative policy analysis. This model can conveniently be modified to study the impact of percolation ponds (Figure 2).

Figure : 2 A FRAMEWORK FOR WATERSHED IMPACT ANALYSIS

(A PERCOLATION TANK EXAMPLE)



6.3 Case Study:

When the percolation pond is constructed, the normal area irrigated gets stabilized and additional area can also be irrigated from out of the enhanced yield from the well. This aspect was examined in some selected ponds situated in different localities. The particulars in respect of one pond in Madurai district are furnished below :-

6.3.1 Cost benefit ratio for the percolation pond constructed in Katchakathi Village (1983)

Capacity of the Pond	= 25,470 m^3
Number of wells benefitted	= 6
Registered Ayacut	= 24.30 hectares
Average area now irrigated	= 8.0 hectares
Gap in irrigated area	= 16.30 hectares
Annual storage in the pond for two fillings 25470 x 2	= 50940 m^3
Volume of water required to irrigate one hectare at 16 ha /28,300 m^3	= 1768 m^3
Water required to irrigate 8.0 ha	= 14144 m^3
Balance available 50940 - 14144	= 36796 m^3
Gap area that can be irrigated with 36796 m^3 of water at 10 ha/ 28300 m^3	= 13.0 ha.
Actual gap area that can be irrigated	= 16.3 ha.
Additional food production from stabilized area at 0.60 tonne/ha	= 4.80 tonnes
Additional food production from gap area at 2.47 tonne/ha	= 40.26 tonnes
Total additional food production	= 45.06 (or) 45 tonnes
Expenditure on construction of pond	= Rs.94,500

Cost of production / tonne = $\frac{94500}{45}$ = Rs. 2100

Useful life of the pond is 10 years

Investment per year = $\frac{94500}{10}$ = Rs.9450

Expenditure on maintenance at 2.5% of the total outlay = Rs.2362

Interest @ 10% = Rs. 945

Total Rs.12,757

Area bridged = 16.30 hectares

Net area benefitted = 24.30 - 16.30 = 8.0 ha

Increase in production = 45 tonnes

Value of the produce at Rs.1500/tonne = Rs. 67,500

Cost benefit ratio = $\frac{67,500}{12,757}$ = 5.29

Cost benefit ratio is 1 : 5.29

The additional area brought under irrigation is 16.30 ha and the total investment on this is Rs. 1,06,312 including expenditure on maintenance and interest on the capital outlay. The expenditure for providing irrigation/ha works out to be Rs.6522. The investment on excavation of an open well of 6 x 6 x 9 m in hard rock area is Rs.40,000. The life of the well is 40 years. This well will be able to command about 1.70 ha normally. The capital cost and interest for providing irrigation for one ha is Rs.2941. The expenses for pumping water with the aid of electric energy for three crops in a year is Rs.790 for one ha. The outlay on provision of irrigation in a surface irrigation system is Rs.40,000 and through tank Rs.25000 per ha. The exceptional cost effectiveness for extension of irrigation through construction of pond would be evident from the above particulars.

6.3.2 Benefits of Pond Construction :

Some of the findings of the study on the benefit are given in table-3.

Table 3: Benefits of Pond Construction:

S.No.	Description	Before construction of pond	After construction of pond
		Rs.	Rs.
1.	Value of dryland per ha. at the zone of influence of the pond	2100	6300
2.	Value of gardenland per ha.	7000 to 9000	11000 to 16500
3.	Net profit in farming per ha per year	6300	10400
4.	Employment potential per ha per year Mandays	205	315

7.0 CONCLUSIONS AND RECOMMENDATIONS :

Construction of percolation ponds conserves the runoff and conveys it to the groundwater reservoir steadily. The yield of wells at the downstream side of the pond increases significantly. The zone of influence depends upon the slope of waterspread area of the pond. After the construction of pond, the yield of water increases phenomenally for every unit of rainfall. Permeability of the soil is primarily responsible for the rate of groundwater recharge from the pond. Recuperation of water in the well after construction of pond is rapid besides increase in quantum. This is aided by the depth of storage in the pond. The pond helps harnessing the runoff efficiently through proper management. The pond exerts a cooling effect on the climate and this microclimate results in economy in water use by crops in the zone.

The benefits of percolation ponds can be summed up as under:

1. It augments groundwater recharge in the zone of influence leading to stabilization and extension of area irrigated.

2. Increases crop intensity and improves the standard of living of the farming community.

3. Provides employment to rural work force.
4. Soil erosion is minimised.
5. Sedimentation of downstream reservoir is reduced.
6. Flash flood is avoided.
7. Flood havoc is reduced.
8. Permanent infrastructure for promoting irrigated farming.
9. Caters to the needs of cattle and community.

10. Helps industry, communication, trade and transport.

11. Fish culture could be pursued profitably.

12. Nitrogen fertiliser can be produced cheaply by growing bluegreen algae.

13. Increase saving in irrigation water for crops in the vicinity.

14. Bird life improves around the pond.

The percolation ponds are designed and constructed with the presently available hydrologic guidelines and norms. These ponds are serving well in the artificial recharge of the ground water reservoir and the benefit of these structures have been well appreciated by the farming community of well commands. However there is scope for further refinement in the hydrologic norms and guidelines for the design and construction of percolation ponds.

The following are the major areas wherein further studies are required to be taken up for further refinement.

1. There is need of a proper mapping of the thickness of weathered zone at a potential percolation site, through geophysical surveys.

2. Repeated infiltration tests at several sites in the tank bed of the proposed site are necessary.

3. Construction of exploitation wells in the command area should be undertaken in tandem with the construction of the tank. This will ensure subsurface drainage of water recharging the aquifers in the tank bed.

4. Combination of several mini-percolation tanks and check-dams with less storage depths but total effective storage equal to that of a single major percolation tank may perhaps be a better alternative in some of the case depending upon geomorphological and climatic situations of the area under consideration. The chances of localised water logging of the tank bed are perhaps less in such structures. They are also easier to construct through community effort and are possibly less expensive.

REFERENCES

1. Chambers R., Rural Development, 'Putting the Last First' Longman London, England, 1983.

2. Goyal S.K. and V.K. Lohani (1988), 'Evaporation Reduction Measures from Water and Land Surfaces for Drought Management', Status Report-11, National Institute of Hydrology, Roorkee.

3. Klien, K K , S N Kulshreshtha, 'Economic Impact of Small Scale Irrigation under Irrigation in Northwestern Saskatchewan, An application of ADIEM,' Agricultural Systems, Vol.30, pp 205-215, Nov. 1983.

4. Mishra G.C. and A.G. Chachadi (1987), 'Retention of Groundwater Recharge Beneath a Spreading Basin', Technical Report-49, National Institute of Hydrology, Roorkee

5. Proceedings of the Workshop on 'Percolatioin Ponds held at Madras , Dec. 12-14, 1990, organised by Centre for Water Resources, Anna University, Madras.

6. Ram Babu, 'Economic Evaluation of Water Storage Structures,' Indian Journal of Soil Conservation, Vol.15, No.3, Dec. 1987.

ACKNOWLEDGEMENTS

The author is extremely thankful to Dr.Satish Chandra, Director, National Institute of Hydrology, Roorkee for his valuable guidance, constant encouragement and constructive criticizem during the course of study. Grateful thanks are also to the working group members of drought studies divisions of the institute, who have provided constructive suggestions during the course of meetings for carrying out the study. Sincere thanks are also to Dr.G.C.Mishra, Scientist 'F' and technical co-ordinator of the division, who has rendered valuable guidance during the study. The author also wished to thank Mr.Avinash Agarwal, Scientist 'C' and Scientist-in-charge of the division who has provided necessary help time to time in carrying out the study.

The author also wishes to express sincere thanks to all central and state government organisation who have provided necessary data and information for carrying out the study. Last but not the least, sincere thanks are due to all other who directly or indirectly helped to make this effect successful.

DIRECTOR	:	SATISH CHANDRA
TECHNICAL COORDINATOR	:	G C MISHRA, SC F
SCIENTIST INCHARGE	:	AVINASH AGARWAL, SC. C
SCIENTIST	:	SUDHIR KUMAR GOYAL
DOCUMENTATION STAFF	:	MAHIMA GUPTA RAJNEESH KUMAR GOEL