Optimizing Household Waste Water

Deepak Hooda*, Baldev Setia

*Research Scholar, NIT Kurukshetra, India

Professor, NIT Kurukshetra, India

Corresponding author email: deepakhooda2010@gmail.com

Abstract

The paper presents a case study of an initiative taken by the Micro Irrigation Catchment Area Development Authority Haryana in utilizing the household wastewater for micro-irrigation. Haryana, being a forerunner in the agro-production, relies heavily on canal and ground water and consumes more than 70% of water for irrigation. But with no perennial river of its own and with the fast plummeting of ground water levels, the water availability is becoming scarce.

Wastewater of set of 17 model ponds as identified by the Haryana Pond and Waste Water Management Authority has been proposed to be utilized for micro-irrigation of the fields. The stored water in the pond is given primary treatment with the help of hydrocyclone filters and conveyed in PVC pipes. The pumps installed for powering the water conveyance are designed on off-grid solar energy.

The paper describes the various parameters and criteria adopted for the design of the scheme and gives the details of two typical model ponds(Keorak and Sagga Village). The methodology is likely to benefit a large number of farmers besides utilising the waste water.

Keywords: Hydrocyclone Filters, Micro Irrigation, PVC Pipes, Waste Water

Introduction and Scope

In present time, the problem regarding scarcity of clean water and water for irrigation is taken granted without much attention towards its conservation. According to Jasrotia et al, an estimated population of 1.24 billion will reside in water scare-countries by 2050. Although seventy percent of the earth's surface is covered by water in different forms, still millions of people in the world don't have access to clean water. Approximately 52% increase in water demand is predicted over the coming years and as per current scenario fresh water is depleting at a faster rate than it can replenish.

Water is most important input for the agriculture, as it is having determining effect on the yield. If crops are not optimally watered, even good seeds along with fertilizers fail to achieve their full potential. India is a global agricultural house and majority of population is directly connected to agriculture. As per survey conducted by Tata Institute of Social Science (TISS) approximately 40% of water demand in urban areas is met with ground water due to which water table in various cities is falling at an alarming rate of 2-3m per year[11]. So as an alternative wastewater can be proposed for irrigation purpose to compensate for water scarcity.

According to international norms, a country can be classified as water stressed and water scarce based on per capita water availability. If per capita availability of water goes below $1700m^3$, it is considered as water stressed and below $1000m^3$, it is considered as water scarce country. India with per capita availability of water as $1544m^3$, presently lies under water stressed category and with the current scenario it is moving towards turning into water scarce country[4].In today’s world one of the prevalent problems is water paucity and agriculture is water intensive. There are limited opportunities to expand the volume of available freshwater assigned to irrigation which means that there is great need of improving efficiency of existing systems.

Methodology

The purpose of this study is to deliver us with a comprehensive study of a system that uses technology that would be a preeminent way of watering agriculture fields. In the present study 2 villages namely Keorak (Kaithal) and Sagga (Karnal) of Haryana are selected on random basis. The basic information of these villages consisting human population, cattle population and no. of ponds are collected. Based on the total human population and stock population, total waste water generated is calculated which inflow to the village pond accounted for various losses.

The area that can be irrigated with the water which inflow to the pond and available for irrigation can be estimated by assuming crop water requirement @ 2mm per day. The stored water in the pond is given primary treatment with the help of hydrocyclone filters of capacity according to design discharge. The treated water is lifted from the pond using off-grid solar photovoltaic pump-sets and delivered to the agricultural fields with the help of pipe networks.

The sedimentation chamber will be constructed before lifting the stored water to separate out the coarse sediments thereby providing clear water[9]. A solar pump of the required capacity will be installed, which will be connected to a filtration unit and after filtration mains and sub mains will be laid by using PVC pipes. One hydrant will be provided on 4 acres and farmers having holdings less than 4 acres will be provided one hydrant. It is envisaged that the study will be able to bring in new area under irrigation and also gainfully utilise surplus water, otherwise going waste.

Irrigation using waste water collected in the village ponds shall reduce dependence on underground water, thereby checking ground water exploitation besides reducing the costs incurred on fuel and electricity costs for pumping out underground water. As water in the proposed system is available throughout the year it shall provide a cushion for farmers and make them less dependent on other sources. These kinds of interventions also help aware and educate the community about optimum and efficient use of water resources.

Further, there are some villages where the ponds periodically receive water from canals under the jurisdiction of the Department of Irrigation and Water Resources, Haryana. It is because such ponds have been revered by the villagers for religious customs and cultural festivities. No waste from the village house hold is allowed to enter such ponds. Depending upon the size of the pond and conventions, the ponds have been receiving a dedicated share of water from the canal system.As per the proposal, the water shall continue to be received by the identified village pond as per the ongoing practice and of the same quantity but will be lifted for micro-irrigation of the fields. This will have the advantage of flexibility of availability of water to the fields besides maintaining the conventional ambience of the village pond. Sagga village falls in the category of utilization of the canal water for micro-irrigation as and when required.

The basic aim of this study is to utilise waste water of pond in the villages after prior testing. In this total inflow water is considered on the basis of water which is consumed by the villagers for daily needs including the water used for cattle. There is allowance for different types of losses such as conveyance, percolation, evaporation etc. Based on the effective inflow in the pond considering all the losses, command area is calculated based on the crop water requirement, which is taken as 2mm per day in the present study. The relevant information of Keorak and Sagga village is depicted in Table 1 and 2 respectively.

S. No.	**Description**	**Reply/Remarks**
1	Name of village	Keorak
2	Name of Gram Panchayat	Keorak
3	Block	Kaithal
4	Tehsil	Kaithal
5	Assembly Constituency	Kaithal
6	District	Kaithal
7	Total number of ponds in the village	5
8	Area of selected Pond (in acre)	34.7 Acre
9	Pond Coordinates (Longitude/Latitude)	29º52'11"N176º28'08"E

10	Total Human Population in village	26851
11	Total live stock in village (Cow/Buffalo)	7077
12	Number of households (Families)	2250
13	Water Source (Live Stock, House Hold, Canal Water)	Livestock & House Hold
14	Availability of water (Yes or No)	Yes
15	**Bore-wells (Public health)**	
a	Number	15
b	Capacity of Motor Pump (HP)	20 HP
c	Ground water table & Length of delivery pipe	180 ft/54.8m
d	Operating Hrs in 24 hours	7 hrs
16	**Bore-wells (Panchayat)**	
a	Number	30
b	Capacity of Motor Pump (HP)	0 2 HP
c	Ground water table & Length of delivery pipe	180 ft/54.8m
d	Operating Hrs in 24 hours	04 hrs
17	**Bore-wells (Personal)**	
a	Number	400
b	Capacity of Motor Pump (HP)	0 2 HP
c	Ground water table & Length of delivery pipe	180 ft/54.8m
d	Operating Hrs in 24 hours	03 hrs
18	If number of ponds is more than one then intimates the %age of effective inflow in the selected pond as per Sr. No.12.	80%
19	Bed Level of Selected Pond (in meter)	234.305 m
20	High flood water level in pond during last 10 years (in meter)	240.400 m
21	Minimum water level in the pond (in meter)	234.914 m
22	Normal water level in the pond (in meter)	235.219 m

Table1. Data of Keorak Village

Net per day available water (Supply Side)

Population of the village	=	26851
Live stock	=	7077
Water consumed in the village per day	=	(26851 x 130) + (7077 x 60)
	=	(3490630 + 424620) litres
Consumption losses @ 20%	=	783050 litres
Balance	=	3132200 litres
Conveyance and evaporation losses@ 20%	=	626440litres
Balance	=	2505760litres

Contribution of this water into the pond under consideration (Pond 1) = 80 %

	=	2004608 litres
Net per day available water	=	2005 kL
Design discharge	=	0.928 m^3/s

Area to be irrigated (DemandSide)

Crop water requirement has been estimated by assuming an average crop water requirement @ 2 mm/day

IntensityofIrrigation 100% (For low water demand crops, i.e.Wheat)
50% (For high water demand crops, i.e. Paddy)

The intensity may be increased during the high-water demand crop season depending upon the availability of water and maintaining equitable distribution. Area that can be irrigated is 247 acres The scheme may be designed to cater for 247 acres

Duration for generation/collectionof water	=	24 hrs
Optimum Duration for supply ofthiswater	=	06 hrs

Conveyance Pipes

As per the provided chak plan, it was decided to provide eight separate arrangements of pump set assemblies with eight different water mains to convey the irrigation water. The design discharge for each unit was obtained as one-eighth of the total discharge available per day. Accordingly, the lines were laid and the critical length of pipeline among the various options tried was 2.20 km. Pipes of different material and different pressure ratings were tried and finally it was decided to provide Unplasticised PVC pipes. Further, under this category different classes and diameters of pipes were tried.

Unplasticised PVC Class 3 Pipe

In the final case DN 160 Unplasticised PVC Class 3 Pipe was tried. The calculated total head required was computed to be 42 mwc. The allowable pressure for the PVC Class 3 pipe is 10 bar(60mwc) and the calculated head of pump is well within the allowable pressure for this class of pipes[8]. Hence, considering due allowance for surge pressure, shut-off head of pumps and temperature effect, the pipe was found to be satisfactory.

Power required andpumps

Power required per pumpsetunit = γ Q H / $\eta_1\eta_2$

= 8535Watts = 11.45HP

Provide a submersible/Mono-set pump of 15 HP. Overall, provide eight motor-pump units of 120 HP.

Solar PowerRequirement

The water from the pond will be pumped/lifted solely using solar photovoltaic pump-sets.

HP requirement per unit ofmotor-pumpset 15 x 8 = 120 HP

I HP of solar source power is equivalent to 1100 Watts.

Therefore, Solar power installation ratingisfor 120 x1100W=132000W

Provide Off-grid Solar Photovoltaic panels to generate and provide energy equal to 132 kW.

FiltrationArrangement

Water lifted from the pond will be routed through a set of compact filtration units of designated capacity and as commercially available. The filtersare:

a) Hydrocyclonefilter
b) Sandfilter
c) Discfilter

Design discharge per unit ofmotor-pumpset = 0.0116 m^3/s = 41.76 kL/hr

Adopt commercially available or prepared hydrocyclone filter units to cater for at least 50 kL/hr (in **suitable denominations**) for one motor-pumpunit.

Illustration:

e.g. Capacity of one hydrocyclone filterunit =25 kL/hr

No. of filter unitsrequired =02

Two sets of each of the three types of filters to be provided with each motor pump assembly.

Or

overall, provide eight sets of filtration units to cater to 400 kL/hr (8 x50).

S.No.	Description	Reply/Remarks
1	Name of village	Sagga
2	Name of Gram Panchayat	Sagga
3	Block	NiloKheri
4	Tehsil	NiloKheri
5	Assembly Constituency	NiloKheri
6	District	Karnal
7	Total number of ponds in the village	6
8	Area of selected Pond (in acre)	8.5
9	Pond Coordinates (Longitude/Latitude)	29°46' 04" N, 76°50'50" E
10	Total Human Population in village	10500
11	Total live stock in village (Cow/Buffalo)	2250
12	Number of households (Families)	1800
13	Water Source (Live Stock, House Hold, Canal Water)	01 Bore well and Canal water
14	Availability of water (Yes or No)	Yes
15	**Bore-wells (Public health)**	
a	Number	4
b	Capacity of Motor Pump (HP)	15
c	Ground water table & Length of delivery pipe	100'
d	Operating Hrs in 24 hours	5
16	**Bore-wells (Panchayat)**	
a	Number	150
b	Capacity of Motor Pump (HP)	1.5
c	Ground water table & Length of delivery pipe	100'
d	Operating Hrs in 24 hours	2
17	**Bore-wells (Personal)**	
a	Number	50
b	Capacity of Motor Pump (HP)	1.5
c	Ground water table & Length of delivery pipe	100'
d	Operating Hrs in 24 hours	2

18	If number of ponds is more than one then intimates the %age of effective inflow in the selected pond as per Sr. No.12.	0% Bore well +80% Canal Water
19	Bed Level of Selected Pond (in meter)	246.5
20	High flood water level in pond during last 10 years (in meter)	254
21	Minimum water level in the pond (in meter)	251
22	Normal water level in the pond (in meter)	252.5

Table2. Data of Sagga Village

Net per day available water (SupplySide)

Connectivity of waterwithpond = RD/9700/TR of

Sagga Minor Discharge as given by the IrrigationDepartment10.00cusec

= 10 x 0.02832

Availability of water = 0.2832 m^3/s

= 3 months in rainy season

Total water inflow = 0.2832 x 90 x 24 x 60 x 60

= 2202164 m^3

Losses (Conveyance, evaporation and percolation losses @40%)

= 880866 m^3

Balance = 1321298 m^3

Rainy/Kharif Season (July, August, September)

This magnitude of water is certainly available during the three months of July, August and September. But the quantity is far too large than the capacity of the pond. It is assumed that the pond shall always be full upto the maximum capacity level during these three months. Since this water is capable of micro- irrigating the area of the chak, the limiting condition for the design of the scheme shall be the size of the proposed chak, which is 105 acres. Therefore, demand decides thecriteria.

Area required tobeirrigated = 105acres

Designdischarge = 0.0393m^3/s

Number of pumpingunitsproposed = 03

Design discharge foreachunit = 0.0131m^3/s

Area to be irrigated (Demand Side)

Crop water requirement has been estimated by assuming an average crop water requirement @ 2 mm/day. Since this water is available,

The scheme may be designed to cater for 105 acres

Duration for generation/collection of water =3 months Annually

Optimum Duration for supply of this water =06 hours/day

Winter/Rabi Season (November, December, January)

The supply of water from the canal being non-perennial, the same quantity of water shall not be available during the period following the three months of supply. In this case, the full capacity that is retained by the pond at the end of September, shall be the limiting condition of design. This stored water is expected to last for three significant months of the Rabi season. Certain postulates have been accepted for the Rabi season:

a) At the end of the rainy season (30th September of every calendar year), the pond is full having a storage of 102510 cum(approx.).

b) This water is to be provided during the three significant months of the Rabiseason.

c) The Rabi season mentioned in Point b. is commencing from the beginning ofNovember.

d) This water should last for the next three months upto about the end of January of the followingyear.

e) The evaporation and percolation losses are @ 10 % during this period and shall be computed on a monthlybasis.

f) About20%(about0.6m)ofthewaterwithrespecttocapacityasinPoint a) shall be the property of the pond and shall be left as Dead Storage for the existence of thePond/Teerath.

Following these postulates, the computations for the availability of water are asfollows:

Reference point of time End of September

Total water storedinpond 102510 m^3

Reserve forDeadStorage @ 20%= 20502m^3

Progressive reduction of water on account of evaporation and percolation from the pond, computed onmonthlybasis 35253m^3

Water remaining upto endof January 67257 m^3 DeadStorage 20502m^3

Balancefordesign 46757m^3

Assured available discharge for Rabi (for 90 days commencing November onwards) 0.024m^3/s

Area that canbeirrigated 64 Acres

Conveyance Pipes

The scheme has been designed on the basis of larger beneficiary area of 105 acres. Pipes of different material and different pressure ratings were tried and finally Unplasticised PVC pipes Class 3 DN 180 was finalised.

Unplasticised PVC Class 3 Pipe DN 180

The calculated pump head was computed to be 40 mwc. The allowable pressure for the PVC Class 3 Pipe is 6 bar (= 60 mwc) and the calculated head of pump is well within the allowable pressure for this class of pipes (IS 4985: 2000). Hence, considering due allowance for surge pressure, shut-off head of pumps and temperature effect, the pipe was found to be **satisfactory**.

Power required andpumps

Powerrequired = γ Q H / $\eta_1\eta_2$

= 9179Watts = 12.30HP

Provide a submersible/Mono-set pump of 15 HP. Overall, provide **three** motor-pump units of 15 HP each. Totalpowerrequired 15 x 3 = 45HP

Solar PowerRequirement

The water from the pond will be pumped/lifted solely using solar photovoltaic pump-sets.

Sourceofpower Solar power

HPrequirement 15HP

I HP of solar source power is equivalent to 1100 Watts.

Therefore, Solar power installation rating is for 15 x 1100W = 16500 W

Provide Off-grid Solar Photovoltaic panels to generate and provide energy equal to

16.5 x 03 = 49.50 kW.

Filtration Arrangement

Water lifted from the pond will be routed through a set of compact filtration units of designated capacity and as commercially available. The filtersare:

Designdischarge = 0.0131m^3/s = 47.16kL/hr

Adopt commercially available or prepared hydrocyclone filter units to cater for at least 60 kL/hr (in **suitable denominations**) for one motor-pump unit.

Results

This scheme shall have following three components:

*Utilization of Canal Water for Micro-irrigation:*Canal water shall be received by the village pond as per the ongoing practice and shall be utilized for irrigation. Since the source of this water is canal, it does not contain any hazardous chemicals etc.

Nevertheless, if required, the water quality shall be checked prior to implementation of projects.

*Solar Photovoltaic Pump-sets(SPV Pumps):*The water from these ponds shall be pumped/lifted using solar photovoltaic pump-sets, which shall help combating environmental pollution and saving on energy front for the State, besides being a zero-maintenancesystem.

*Underground Pipeline (UGPL):*Conveyance of water from village ponds shall be done by underground pipelines. Conveyance of irrigation water by UGPS leads to a saving of up to 20% - 30% water, which is otherwise lost in evaporation and seepage losses compared to open channels.

Based on the data of both villages (Keorak and Sagga) and considering different design parameters, water network system is designed using PVC pipes of designated diameters which is directly related to design discharge. In table 3 and 4, detailed design information is depicted of Keorak and Sagga village. In figure 1 and 2, water network system consisting of PVC pipes, pump house and selected pond is shown of Keorak and Sagga village.

Table3. Detailed design information regarding pipe network system of Keorak village

Present Design DN 160 PVC Class 3 Pipe		
Parameter/ Description	**Value**	**Units**
Total Design Discharge	0.0928	m^3/sec
Number of pumps proposed	8	No.
Flow (Pump Capacity) @ one hydrant per pump set unit running at a time	0.0116	m^3/sec
Pipe OD	0.160	m
Pipe ID	0.147	m
Velocity	0.68	m/sec
Hazen William Constant	120	
Head loss (mwc/ km)	4.41	mwc/km
Length of Critical pipe route (calculation based on the chak plan)	2200	m
Friction loss in pipeline	9.70	Mwc
10% margin for fitting losses etc.	1.00	Mwc
Total of friction and minor losses	10.70	Mwc
Head required at hydrant	25.00	Mwc
Static Head	3.00	M
Hydro cyclone filter losses	3.00	M
Total Head Required	41.70	Mwc
	42.00	Mwc

Table4. Detailed design information regarding pipe network system of Sagga village

Present Design DN180 PVC Class 3 Pipe		
Parameter/ Description	**Value**	**Units**
Flow (Pump Capacity) @ one hydrant running at a time	0.0131	m^3/sec
Pipe Diameter and MOC		
Pipe OD	0.180	m
Pipe ID	0.166	m
Velocity	0.607	m/sec
Hazen William Constant	120	
Head loss (mwc/ km)	3.10	mwc/km
Length of Critical pipe route (calculation based on the basis of connecting different nodes as per the chak plan)	1.500	Km
Friction loss in pipeline	4.65	Mwc
10% margin for fitting losses etc.	0.50	Mwc
Friction and other losses	5.15	Mwc
Head required at hydrant	25.00	Mwc
Static Head	6.00	M
Hydro cyclone filter losses	3.00	M
Total Head Required	39.15	Mwc
	40.00	Mwc

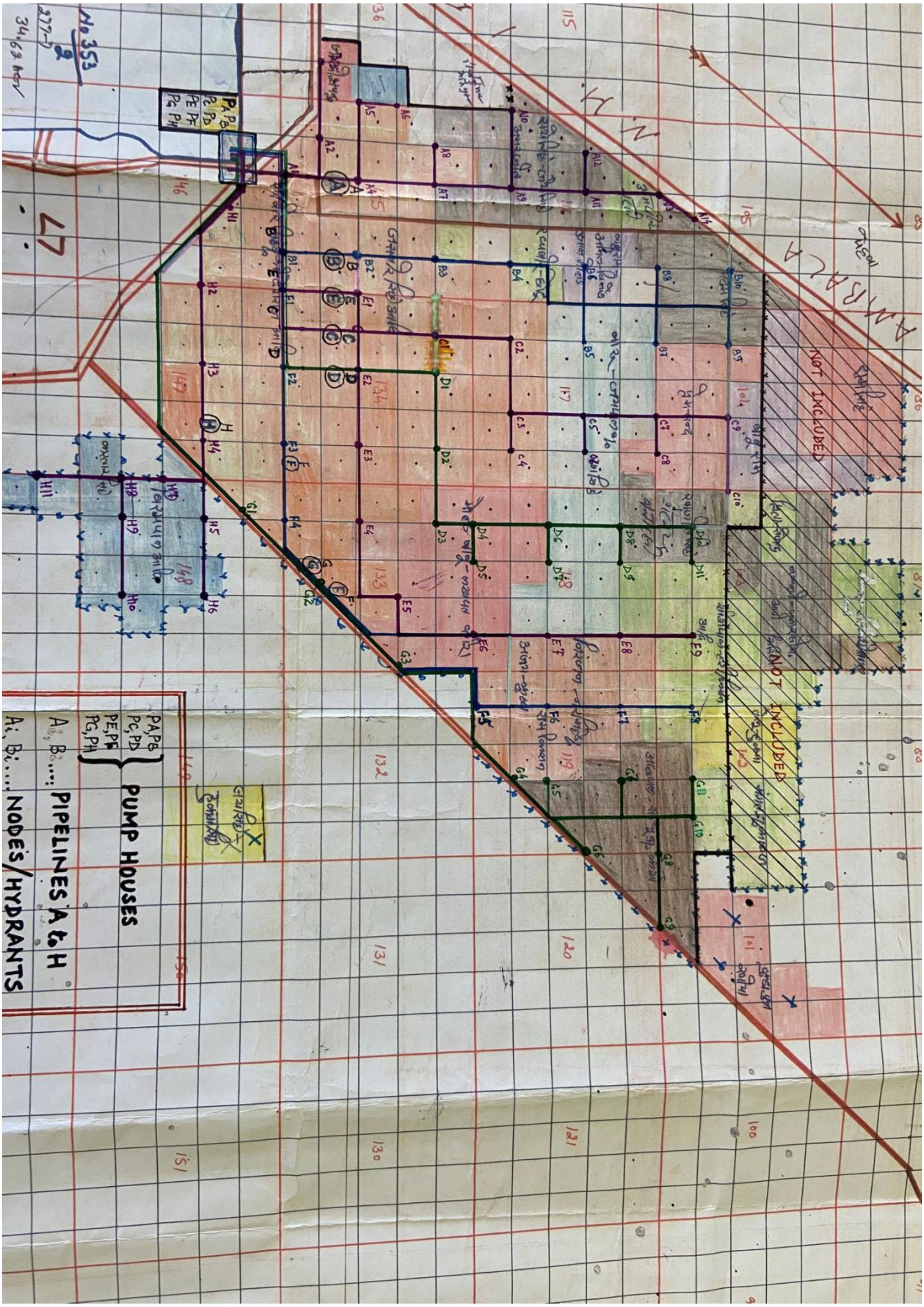

Figure1. Chak plan of Keorak village showing pipe distribution system

Figure2. Chak Plan of Sagga village showing pipe distribution system

Recommendations and Conclusion

As per the study carried out, different recommendations have been determined for both village due to difference in population and different source of water supply.

Keorak village

1) Eight 15 HP Submersible/Monoblock pumps (Marked PA, PB, PC, PD, PE, PF, PG and PH in the Chak Plan) to lift water from the pond to the desirablehead.
2) Eight sets (Three for each of the three units of motor-pump set) of Hydrocyclone filters, Sand filters and Disc filters to be installed immediately outside the pond for filtration of the liftedwater.
3) Provide commercially available or prepared filter units to cater for at least 50 kL/hr (in **suitable denominations**) for one motor-pump unit. Overall, provide eight such sets of each of the three types of filtration units to cater to 400 kL/hr (8 x 50).
4) Eight lines of DN 160 PVC Class 3 Pipe [8] laid underground along the Murabba-line/Killa-line/Pathway to be used throughout for conveying water as per the nodes on the Chak plan. All nodal points to be provided with individual butterfly valves for operation of the micro-irrigation sprinkler units. The nodal points/hydrants may be altered as per requirements of the site conditions and in consultation with the competentauthorities.
5) Power to run all the three pump units to be provided by Solar power of an installed capacity of 132 kW.
6) An optimum duration of 6 hours per day to run the pump to provide water to thefields.
7) Scheduling and operation of the pump and the distribution system to be taken care of by the **Water Users Association** at the villagelevel.
8) The submersible pump assembly floating in the pond should preferably be enclosed in an improvised wire mesh of reasonably wide extent so as to ward off any floating or semi-floating undesirablematerial.
9) The solar power installations shall be duly protected against the menace of wild animals with the help of a wiremesh.

Sagga Village

1) Three 15 HP Submersible/Monoblock pumps to lift water from the pond to the desirablehead.
2) Two sets of Hydrocyclone filter, Sand filter and Disc filter for each pump house to be

installed immediately outside the pond for filtration of the lifted water. For three pump houses, 06 filter units shall be provided or in such denominations to take care of 180 kL/hr (60 x3)

3) DN180 PVC Class 3 Pipe [8] laid underground to be used throughout for conveying water as per the nodes on the Chak plan. All nodal points to be provided with individual butterfly valves for operation of the micro-irrigation sprinkler units. The nodal points/hydrants may be altered as per requirements of the site conditions and in consultation with the competentauthorities.
4) The scheme has been designed for 105 acres which will benefit from the scheme during the rainy season. However, the beneficiary area during the non-rainy season shall be 64 acres which will receive water during November, December and January. These 64 acres shall be identified/decided by the Department/Gram Panchayat/Water Users Association).
5) Power to run the pump to be provided by Solar power of an installed capacity of 49.50kW.
6) An optimum duration of 6 hours per day to run the pump to provide water to thefields.
7) Scheduling and operation of the pump and the distribution system to be taken care of by the **Water Users Association** at the villagelevel.
8) The submersible pump assembly floating in the pond should preferably be enclosed in an improvised wire mesh of reasonably wide extent so as to ward off any floating or semi-floating undesirablematerial.

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