An Investigation into the Causes of Water Logging at Zauro Polder Pilot Project Scheme in Birnin Kebbi, Nigeria

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Abstract

The Zauro Polder Project (ZPP) was designed to irrigate over 11,000 ha of arable farmland in Kebbi State. The area is equipped with a 2.65km flood protection dyke, 3.5m high, a temporary pumping station with a generator, a main canal which is connected to compensation reservoir four lateral canals and a collector drain. The source of water is man made diversion channel from the Rima River from which water is pumped into the scheme. In carrying out this study, the channel selected is not among those used for irrigation in the scheme. The channel ends were covered with metal sheets to prevent leakage. The slope was chosen to be 2:1 because of the soil type of the side, which is sandy clay loam. A total timing of 242 min was spent to obtain a total transmission loss of 123.65 mm/min. The rate of seepage loss at its parameters in which the highest transmission loss value is 15.72 mm/min was observed, in the second reading after the first reading of transmission loss value of 15.61 mm/min. The first transmission loss value of 14.94mm was observed in channel II and it gradually decreased to 2.93 after 4 hr 6 min.

***Keywords**: Seepage, flooding, water logging, transmission loss.*

Introduction

Water is life; it marks the beginning of life, and it is the medium of life as there is no plant or animal that can survive for a long period without using or depending on water in one way or the other, directly or indirectly.

The Zauro Polder Project (ZPP) was designed to irrigate over 11,000 ha, which is being managed by 7,790 farmers (Wakuti 1980). The scheme was designed for the Sokoto River Basin Development Authority (S. RRBDA) to be used as a model for the farmers The scheme is 100 ha and it is sited on the northern part of Birnin Kebbi along the southern bank of Sokoto Rima valley.

The area is equipped with a 2.65km flood protection dyke, 3.5m high, a temporary pumping station with a generator, a main canal which is connected to compensation reservoir four lateral canals and a collector drain. These infrastructures are expected to enhance water distribution and management in order to effectively operate the surface irrigation basically practiced in the scheme.

This consists of main canal 545m long, four lateral canals of 5290m of length. The main canal has bed width of 0.5m, inside is 1:1:5 with a clear depth of 1.05m. Also, there are four lateral drainage canals having a length of 4700m, which collect the drainage water from basins and then convey them to two secondary drainage canals having a total length of 745m. Water is collected in the collector reservoir. The drainage water is discharged by gravity outlet.

The main problem encountered in the scheme is that of water logging which is associate with the rise in the ground water table. This could turn the available farm land into an unproductive area due to salinity and alkalinity. Since the inception of the scheme in 1982 the conditions have kept deteriorating.

It was imperative to investigate the cause of water logging at the Zauro Polder project as the situation kept deteriorating presently less than eighty percent of the arable land in the scheme is cultivatable (Isrealsen 1979).

Water logging soil means a soil saturated with water in the root zone. "Also a soil is said to be water logging when the ground water table gets connected to soil water in the crop root zone and remains like this for the remaining period in a year.'' (Michael and Ojha 2006).

It may be temporary, seasonal or permanent. Soil having permanent ground water near the surface is considered to be water logging. Water logging may or may not be associated with Salinity. Water logging may also occur as a form of standing water in the farm, which does not lower with time (Murty 1985).

This project is aimed at determining the causes of water logging in the pilot scheme of Zauro Polder project (ZPP). The results of this study will be used to provide advice to the practicing farmers in the area on way of solving the problem of water logging to some places and draught at other places in the scheme.

Materials and Methodology

The scheme is within the Birnin Kebbi local government area. It is overlooked by Birnin Kebbi town (2 km away) that is 120 km southwest of Sokoto town. The Rima River flows along one side of the project. The project area lies Northeast of Birnin Kebbi at $4^{o}10'$ East to $4^{o}31'$ East and $12^{o}29'$ North to $14^{o}42'$ North at the southern bank of the river.

The source of water is man made diversion channel from the Rima River from which water is pumped into the scheme. The project area is surrounded by an earth–filled dyke that is designed to protect the farmland from flooding by the river. There is a brick–lined main canal and four lateral canals that are in trapezoidal shape with some growing grasses inside. There is one drain at the lower end of the project which discharges water by gravity back to the river.

The polder project has one main pumping station located at the intake collector reservoir with three intake pipes. The pump station consists of six water pumps of which three were functioning. There was also one electrical power generator to power the pumps.

Field Experiment

Ponding Method

In carrying out this study, the channel selected is not among those used for irrigation in the scheme. This is because the shape of the old channels has being altered and secondly to obtain the maximum seepage loss rate of the silt, as seepage loss value is high in a newly constructed canal than in old and silted channels. The volume required is also adopted because of the difficulty of adding large quantity of water into the pond especially if the channel is long. On the strength of this, two trapezoidal channels were constructed with the following specifications:

Channel	Depth	Bed width	Length
A	30 cm	30 cm	100 cm
B	30 cm	30 cm	100 cm

The channel ends were covered with metal sheets to prevent leakage. The values were chosen in small dimensions so that the changes of water level can be manifested easily in small ditch than in a large ditch of water. The slope was chosen to be 2:1 because of the soil type of the side, which is sand – clay loam, as discovered from the design of slope of a channel. (Varshney 1979). The design slope value was chosen to ensure stability of the channel and for the safety of the channel. The channel size and shape was excavated, the depth and width was extended to 32 cm to accommodate the metal sheets at the ends of the channel. This was preceded by making the side of the channel at an inside slope to 2:1.

Infiltrometer of inner cylinder (30cm) diameter and outer cylinder (60cm) ring height 25cm to pond water on the ground surface were used to measure infiltration rate (Musa 2004). A stopwatch was used to observe the timing of infiltration, while a ruler was attached to measure the water level. The infiltration experiment was carried out at three locations of the channel numbers 1, 2 and 3. Channels 1 and 2 were observed to have clay with some sandy loam areas while channel 3 was sandy clay loam.

The rings were inserted into soil by placing a plank across the ring and tapping gently until the rings had gone into the soil to a depth of 11cm. The outer ring was to prevent the surrounding edge effect of the inner ring while the inner ring had a metal rule attached to the inner side which allows the reading of the water level as infiltration progresses (Musa 2004). During the installation of the outer ring, care was taken to centralize the radial distance between the two rings (concentric). The depth was checked again with ruler to ensure a perfect level before commencing the experiment.

A small quantity of grass was placed in the inner and outer ring of the infiltrometer to avoid pudding water in the cylinder. Infiltrometer was put in place, water was poured into the inner and outer rings and simultaneously the watch was started.

When the inner ring has been filled up to the reference point, the outer ring was also filled immediately to the same reference point to maintain a constant average infiltration rate head. The water level in the inner ring was monitored as in the outer ring. A convenient time interval was chosen for easy readings from the Infiltrometer rings.

Results and Discussion

The Zauro Polder Project (ZPP) is a fairly flat land surface made up of sandy-clay loam soil with alluvial deposit which dominates almost out of the total soil in the area. The soil being clay-loam soil has a low tendency for permeability in percolation and hence waterlogging. Also the construction of the scheme was carried out through direct labor, which resulted in an uneven leveling of the scheme, hence the problem of water logging.

The effect of variation in water level in the channel is illustrated in Table 1. It was observed that the higher the water head the more seepage loss and there was no uniformity in the losses. The effect of variable head of seepage is an important factor in determining water losses in channel.

Table 1. Determination of seepage rate at ZPP.

No. of reading	Water height in channel (cm)	Time interval (min)	Transmission losses mm/min.
1	9	5	15.61
2	9	3	15.72
3	8.5	4	5.58
4	12	10	6.62
5	12	8	6.58
6	10.8	11	4.74
7	10.2	13	5.76
8	5	4	2.34
9	10.2	5	8.7
10	10.5	7	6.58
11	6.5	5	3.66
12	7.5	10	3.24
13	10	11	2.88
14	12	19	2.05
15	7.4	10	2.90
16	7.6	10	2.80
17	7.8	9	2.80
18	7.4	9	2.30
19	8.2	11	2.94
20	7.6	18	2.64
21	7.7	5	2.7
22	7.1	5	1.25
23	6.4	5	1.98
24	8.5	5	2.64
25	7	5	0.71
26	6.6	5	1.26
27	5.9	5	0.54
28	9.2	5	2.11
29	8	5	0.71
30	7.6	5	1.25
31	6.9	5	1.15
32	6.2	5	0.91

A trend of gradual reduction was observed in the transmission loss from the start to the end of the observatory period. A total timing of 242 minutes was spent to obtain a total transmission loss of 123.65 mm/minutes. It is important have to note that the time intervals area not the same.

Table 2 shows results of transmission loss in equal and unequal time interval at channel 1. It was observed that when pouring water into the channel, there was a rapid fall of the water head due to rapid infiltration rate of the soil initially. This was because the existing soil voids have not been filled up with water. However, the falls become gradual after some time. Water seeps into the soil due to stress of water movement vertically and laterally at the channel sides and bed respectively. The higher the water levels the more the stress. A reduction in seepage was observed when there was a fall in water level.

Table 2 shows the rate of seepage loss at its parameters in which the highest transmission loss value is 15.72mm/min was observed, in the second reading after the first reading of transmission loss value of 15.61mm /min. A gradual decrease in the transmission loss of between 15.72mm/min to 0.54mm/min after 3hr 15min. An average value of 3.9mm/ min was calculated for this channel.

In Table 3, the first transmission loss value of 14.94mm was observed in channel 2 and it gradually decreased to 2.93 after 4hr 6minutes and the mean transmission loss value was calculated as 5.796mm/min. Generally, it was observed that the highest transmission rate of 14.94mm/min was observed under the head of 9 cm while a transmission loss value of 2.93mm/min was also observed under the head of 4.7cm.

Table 2. Result of transmission loss with equal time interval of 5min at channel 1.

No. of reading	Water height in channel (cm)	Time interval (min	Transmission loss (mm/min)
1	9	5	15.61
4	8.5	5	5.7
10	10.2	5	8.7
12	6.5	5	3.66
22	7.7	5	2.70
23	7.1	5	1.25
23	6.4	5	1.98
25	8.5	5	2.64
26	7	5	0.71
27	6.6	5	1.26
28	5.9	5	0.64
29	9.2	5	2.11
30	8	5	0.71
31	7.6	5	1.25
32	6.9	5	1.25
32	6.2	5	0.61

Table 3. Result of transmission loss in channel 2.

No. of reading	Water height in channel (cm)	Time interval (min)	Transmission loss (mm/min)
1	9	4	14.94
2	10.5	5	9.78
3	7.5	5	7.44
4	8.9	6	8.39
5	8.6	7	8.34
6	8.2	6	7.44
7	8	6	7.10
8	9.2	6	6.59
9	9	10	7.02
10	11.2	8	5.98
11	6.8	6	5.74
12	6.5	6	6.83
13	7.5	10	5.69
14	6.5	10	4.72
15	7.2	9	4.94
16	7.0	10	4.01
17	5.2	11	4.64
18	7.5	18	3.75
19	7.0	5	6.81
20	14.0	5	5.59
21	11.5	5	4.41
22	9.5	5	3.92
23	7.7	5	3.44
24	6.1	5	2.91
25	4.7	5	2.93
26	18.2	5	6.40
27	15.4	5	4.96
28	13.2	5	4.68
29	11.1	5	3.48
30	9.5	5	3.24
31	8.0	5	3.24
32	6.5	5	3.18

The tests on channel 2 show high transmission losses initially as observed in test channel 1 with similar reasons after that, there was a gradual drop in loss rate. The tests were conducted within 3 days.

Tables 2 and 4 are the tables of constant time of the both two channels. These tables were sorted out to compare the transmission loss values varies, this may be due to soil characteristics, and strata configuration. The average mean values of transmission loss of the channels were calculated and chosen as the rate of seepage loss in the scheme.

Table 4. Transmission loss under different water height with constant time (5 min) interval at channel 2.

No. of reading	Water height In channel II (cm)	Time interval (min)	Transmission loss (mm/min)
2	10.5	5	9.78
3	7.5	5	7.44
19	17.0	5	6.81
20	14.0	5	5.59
21	11.5	5	4.41
22	9.5	5	3.92
23	7.7	5	3.44
24	6.1	5	2.91
25	4.7	5	2.93
26	18.2	5	6.84
27	15.4	5	4.96
28	13.2	5	4.68
29	11.1	5	3.48
30	9.5	5	3.24
31	8.0	5	3.24
32	6.5	5	3.18
33	5.0	5	2.63

It was also observed that the infiltration increased with time until it got to its peak and remained constant afterwards. The infiltration rate at the second fringe was slightly faster than the first fringe. However, it was much slower at the bottom since after first one hour there was no infiltration. Figures 1 to 3 shows the various infiltration rate for the land under the influence of the various channels which all shows a large in take of water before finally stabilizing towards the final hours of the test with channel area taking more water hence more time.

From the topography of the area pilot scheme (ZPP), it is clear that some areas of the scheme are waterlogged, while some areas are prone to draught. All those areas having elevations less than 100cm are waterlogged, as there is no possibility of surface outflow. Water logging occurs also as a result of lack of effective and the inability of the management to disilt and reconstruct the drains as well as the secondary canals as the tributaries do not have access to the outlet which brings about a standstill of water on the land thereby causing waterlogging.

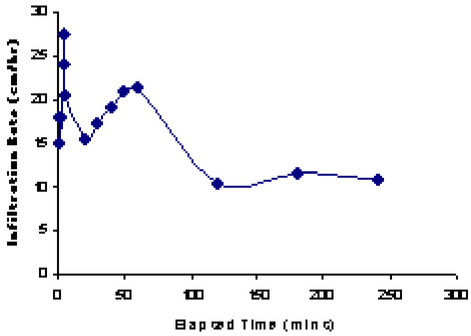

Fig. 1. Infiltration rate of the land under the influence of channel 1.

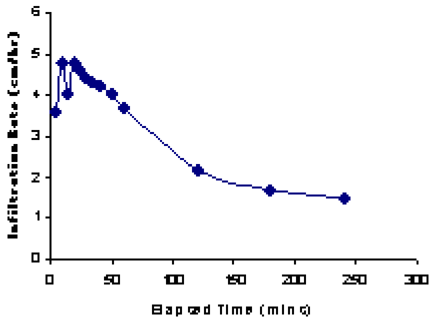

Fig. 2. Infiltration rate of the land under the influence of channel 2.

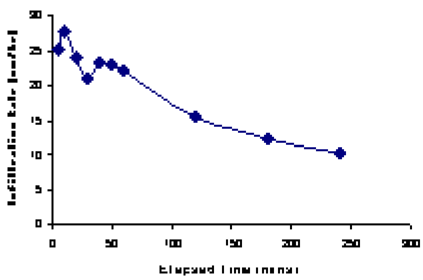

Fig. 3. Infiltration rate of the land under the influence of channel 3.

Also, over-irrigation by farmers, under the wrong impression that the more the water applied to the crop the more the yield which brings about water logging in the scheme. Also bad tilling, creating obstruction to the flow in the farm by way of depressions, ponds, and improper land grading, seepage through a vast network of unlined canals, contributes to water logging in the scheme. Irrigation of unsuitable soil, i.e. soil with more depth of highly clayish soil, brings about water logging.

Erosion is also a problem that contributes to the waterlogging in the scheme because the water that has been collected through drains from the town is emptied into the irrigation area. The water, which is accompanied with silt usually, erodes and deposit materials into the scheme, which also causes waterlogging.

The study area is located within the fadama zone of the lower elevation of the eastern boundary of Birnin Kebbi town. However, there is a tendency for ground flow of water from the farm and consequent accumulation of water at points of lowest elevation.

Water logging occurs mainly in areas where there are clay and loamy soil which are impermeability and must have contributed immensely to poor outflow and consequent rise in the water table, hence waterlogging. The second reading was taken after the bubbles disappeared. This implies that the volume of air was removed from the soil in contact with water and then the air voids were replaced by water. This is why the transmission loss is higher than the initial reading of 15.61mm /min. The transmission loss continues decreasing gradually to the least value of 0.54mm /min after 5.15hr. As the depth of water was increased, the transmission loss also increased to 2.11mm/min. this also shows that transmission loss decreases when the seepage was deep. The average value of 3.9mm/min was calculated from this channel.

Conclusion

Four areas are water logging and can be located on the study area which causes mainly lack of surface outflow, lack of effective drainage, lack of adequate percolation, excessive inflow of water and increase in the underground water table height. These have affected the various farmers and there output as there farmland available for cultivation has been reduced and the presence of excess water on the farmland has reduced the crop yield of the farmers.

Recommendation

To improve the conditions in the pilot scheme the following recommendations should be adopted. A proper leveling of the site should be carried out so that free surface outflow can be achieved. The drains and the canals should be regarded so that smooth inflow and outflow can be obtained. There should be adequate monitoring of the lateral canals in order to forestall illegal activities of the farmers. A further study should be carried out to determine the relative elevations of the farm and drains in order to ascertain the adequacy of outflow.

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