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Current Hydraulic Parameters of Drainage Channels in Kore Sector Of Kano River Irrigation Project (KRIP) Phase I

*Salisu, A[1]. M.A. Oyebode[2], A.A. Abdullahi[3] and M. Audu[1]
[1.] *Department of Soil Science and Agricultural Engineering, Usmanu Danfodiyo University, P. M. B. 2346, Sokoto , Nigeria.*
[2.] *Department of Agricultural Engineering, Ahmadu Bello University, Zaria*
[3] *Department of Soil Science, Ahmadu Bello University, Zaria*

ABSTRACT : *Study was conducted to assess the current condition of drainage channels of Kore sector in Kano River Irrigation Project (KRIP) phase I with a view to evaluate field and collector drains hydraulic parameters. The result shows that the bed slopes and geometry of both field and collector drains have drastically change thereby pounding the water rather than evacuating it. The carrying capacity of the field drains are 0.16, 0.49 and 0.54 m^3/s for Kore I, II and VI respectively. The value exceeded the design value of 0.03m^3/s as a result of erosion which have expanded the drains dimensions. The estimated Manning's roughness coefficient using the determined discharge runoff of 0.0059m^3/s from the drains was found to be 0.6, a value far above the design discharge of 0.03 for the field drains. Even though the runoff recorded during the irrigation period was found to be adequate and can be handled by the drains' current carrying capacity however, farmers' practice during the rainy season period pose a serious challenges on the overall existence of the project.*

KEY WORDS: *drains, hydraulic parameters, discharge runoff, KRIP.*

I. INTRODUCTION

Irrigation continues to be an important force in agricultural development. The expansion of cultivable land and intensification of food production through the use of irrigation has made a substantial contribution in increasing food production all over the world (Umali, 1993). Irrigation also keeps farmers especially rural dwellers busy throughout the year, it is an insurance against crop failure and crops that cannot be grown during the rainy season could be grown by irrigation in the dry season (Hillel, 1987). For developing countries, its contribution to the attainment of development objectives of food security, poverty alleviation and improvement of livelihood of the rural populace has been significant (Umali, 1993). Although, irrigated area accounted for only 1 percent of global cropland in 1986, it accounted to more than 33 percent of the total world food production (Umali, 1993). World irrigated area grew from 94 million hectares in 1986 to 237 million hectares in 1990 (World Bank – UNDP, 1990) In fact almost 60 percent of rice and 40 percent of wheat production in developing countries is on irrigated land (World Bank UNDP, 1990). The development of water resources especially for irrigation purposes in Nigeria dates back to the pre-colonial era, with irrigation potential estimates in Nigeria vary from 1.5 to 3.2 million hectares. The latest estimate gives a total of about 2.1 million hectares of which about 1.6 million is from surface water and 0.5 million hectares is from groundwater (FAO, 2005). As s result of FAO and U.S. Bureau of Reclamation studies in the early seventieth three pilot public irrigation schemes were developed, namely: Bakalori Irrigation Scheme, Kano River Irrigation Scheme and Chad Basin scheme. The success of these pilot schemes coupled with five year drought (1970-1975) led to the establishment of 11 River Basin Development Authorities (ICID, 1995). Kano River Irrigation Scheme been one of the oldest formal irrigation project have start to develops problems such as high water westage resulting in environmental pollution (Adewumi, 1985), soil deterioration due to salinity and alkalinity (Muhammad, 1987), salt build up and waterlogging condition (Othman et al., 2006) in some part of the project area lead to this study with a view to evaluate the adequacy of surface drainage facilities under farmers' operating conditions.

Theory and drainage design specification

Channel and drainage ditches in the project area are all open conduits, trapezoidal in shape meant to convey water in and out of the project area. The design involves determining the carrying capacity, channel slope, cross section dimensions that include; bottom width, design depth, side slope, top width and free board (Arora, 2007). Basic equations for flow in open conduit design are continuity equation

$$Q = VA \quad \text{------------------------------}1$$

and Manning's formula

$$V = \frac{R^{2/3}S^{1/2}}{n} \text{ - } 2$$

Combining equation 1 and 2 to givew

$$Q = \frac{AR^{2/3}S^{1/2}}{n} \text{ -} 3$$

Where

Q-discharge in m^3/s S–Bed slope % A–Cross sectional area m^2

R – Hydraulic radius V–Running velocity, m/s n–Manning's roughness coefficient

Under the normal action of channel flow, deposition and bank erosion the trapezoidal and triangular sections tend to become parabolic (Glein et al., 1993). Parabolic cross section approximate that of natural condition and the following expressions indicate dimensions of the parabolic cross section and formulae for computing hydraulic characteristics are defined thus:

$$Area\ A(m2) = \frac{2}{3}td \text{--} 4$$

$$wetted\ perimeter\ P(m) = t + \frac{8d^2}{3t} \text{ ------------------------------------- } 5$$

$$Hydwraulic\ radius\ (m) = \frac{dt^2}{15t^2+4d^2} \text{ -------------------------------------} 6$$

Where:

d = depth, (m) n = Manning's coefficient t = top width (m)

II. MATERIALS AND METHODS

Detail location of the study area.

Kano River Irrigation Project (KRIP) lies between longitude 8° 30' E to 9° 40'E and latitude 11° 30'N to 12° 03'N within the Sudan savannah zone of Nigeria (NEDECO, 1974). It has three distinct climatic seasons; warm rainy season June – September, cool dry season October – February and hot dry season March – May. Rainfall is highest in July and August with an average of 860 mm. Mean daily temperature ranges from 20° to 38° C with highest temperature in the month of May and Lowest in the month of January. Geologically, the area belong to northern Nigerian basement complex with dominant rock type of granitic gneisses and schist weathered by rivers and rivulets (NEDECO, 1979). The project has a total of 38 sectors with Kore sector been the largest in the project area, having an area extent of 2,315.2 ha and is about 40 km away from Kano city along Kano – Zaria express ways. The sector receives water from Main canal (West Branch Canal, WBC) via Kore lateral canal (Kor. LC) and sub laterals (1SLC, 2SLC, 3SLC and 4SLC) lined canals with total length of 11,933 m. The Kore Distributory canals (DC) having total length of 26,976 m takes water from this lines canals to irrigate the area through 204,046m length of field channels (NECCO, 1981).

Description of selected stations and data collections.: Kore sector is divided into six areas, I – VI out of which three areas Kore I, II and VI were selected. Kore I is at the head of the sector receiving its water immediately after the sector turnout, Kore II is served by a sub-lateral (Kor. 1SLC) in the middle, Kore VI receiving its water from a diversion box serving Kore IV, V VI via sub lateral canals. In each area a farmers' plot, a field drain and a collector drain were selected. Data collection for the study was conducted during 2007/2008 irrigation season, measurements taken include: field and collector drains bed slope and fields cross slopes using survey equipment, flow discharge in the field channels, discharge into the furrows as well field and collector drains geometry (top widths, depths) at various positions. From dimensions obtained and using appropriate equations as ----was used to determine cross sectional area, A, wetted perimeter, P and hydraulic radii R.

III. RESULT AND DISCUSSION

Drain bed slopes and shape geometry

Collector and field drains were all constructed in earth materials and with usage and aging they have eroded or silted up, changing both in dimension and bed slopes. Measurement of drains dimensions were made at the three selected stations, the results are presented in Table 1 and 2 for field and collector drains respectively. The field drainage system is an earth channel designed to cater for a discharge of 0.03 m^3/s per 11.3 ha field size with an end spillway consisting of an inlet structure and outlet pipe 250 mm diameter with capacity of $0.09m^3/s$ per 11.3 ha standard field size with 225 mm bottom width, 400 mm depth, 250 mm water depth having side slope of 1:1. The Manning's roughness coefficient is 0.03 on long term of bad condition with hydraulic radius stands at 0.12. The current measured top widths of 2460 mm, 1450 mm and 2280 mm for Kore I, II and VI shows an increases of between 40- 140% of its design value of 1025 mm but the flow depths for Kore II and VI slightly increased to 270 mm and 260 mm whereas that of Kore I decreased to a value of 210 mm against the designed value of 250 mm. Erosion and sedimentation lead to changes in the drains dimension which lead to changes in drains cross sections and also affect the hydraulic parameters. The hydraulic radii have increased to 0.14, 0.17 and 0.18 m for Kore I, II and VI against the design value of 0.12m. Similar variation was also found to be with selected collector drains in the sector. The slopes were determined from best fitted slope lines plotted with reduced levels versus measured distance along the selected drains reaches. The slopes determined from the regression equations were found to be 0.002, 0.036 and 0.018 for Kore I, II and VI respectively which are all higher than the designed value of 0.001. The slope line of the field drain in Kore I show a very poor flow pattern as indicated by the low R^2 value. Collector drains in Kore I and VI allows build up and storage of water rather than evacuating it from the area which lead to the area being waterlogged and saturated by induced seepage. Moreover, based on the above measured dimensions expected capacity of both field and collector drains was calculated for long term condition using continuity and Manning's equations. The result as presented in Table 3 show that the value 0.16, 0.40 and 0.54 m^3/s for the drains are higher than the design field drain discharge value of 0.03m^3/s. This is attributed to the widening of the drain cross section due to erosion and farmers' activities within the drains. Similarly, collector drains was designed on roughness coefficient of 0.60 on long term basis with design discharge of 2.65l/s/ha but the current carrying capacities was found to be 5.04, 0.40 and 2.03m^3/s for Kore I, II and VI respectively.

IV. CONCLUSION

There is in general, widening of cross section dimension of virtually most of field and collector drains with fewer affected by silt deposition due to channel erosion and distortion of the bed slope, transportation of eroded materials by both water and human activities in the project area. It is therefore, important for collaboration between managing agency and water users for active participation in routine maintenance of all drainage facilities as well as to consider rehabilitation programme so as to restore to the design requirement of the affected areas in the project.

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Table 1: Dimension and Hydraulic Parameters of Field drains

Stations	**Drain top width t (cm)**	**Depth of flow, d (m)**	**Wetted perimeter, P (cm)**	**Hydraulic radius, R (m)**	**Area, A (m)**	**Slope, S**	**Discharge, Q (m^3/s)**
Kore I	2.46	0.21	2.51	0.14	0.34	0.0027	0.16
Kore II	1.45	0.27	1.58	0.16	0.26	0.0360	0.49
Kore VI	2.28	0.26	2.36	0.17	0.40	0.0178	0.54

Table 2: Dimension and Hydraulic Parameters of Collector drains

Stations	**Drain top width t (cm)**	**Depth of flow, d (m)**	**Wetted perimeter, P (m)**	**Hydraulic radius, R (m)**	**Area, A (m)**	**Slope, S**	**Discharge, Q (m^3/s)**
Kore I	4.80	4.80	5.07	0.055	2.24	0.055	5.06
Kore II	2.96	2.96	3.02	0.023	0.51	0.023	0.40
Kore VI	4.00	0.46	4.14	0.049	1.23	0.300	2.03

Table 3: Fields and Collectors drain capacities (calculated values).

Stations	**Field drain capacity Q (m^3/s)**	**Collector drain capacity Q (m^3/s)**
Kore I	0.16	5.04
Kore II	0.49	0.40
Kore VI	0.54	2.03