Environmental impact of a drain system failure: A case study

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THE MAIN DRAINAGE system at the Agricultural Engineering Department of the Kaduna Polytechnic was constructed in 1977. It was designed to be self cleaning with a carrying capacity of 2.42m^3 sec $^{-1}$.

Causes of failure

Over the years sediment started to build up at the channel bed as a result of inadequate channel bed slope, the absence of a proper outlet for the system and poor maintenance culture.

Tree roots probing through the drainage channel walls ad undermining the channel section, at various points, caused the structural damage of the system at such points. Thus, the system started to fail functionally and to deteriorate structurally.

Environmental impacts

With time, the damaged channel became a mere water trap as water stagnated in it, thereby creating a favourable condition for mosquitoes, flies and other vectors of pathogenic organisms to breed. Putrefaction and the resulting offensive odour from the trapped organic and other litters turned the system into a slum and, hence, into an environmental degradation and a health hazard.

Methodology

In order to solve the aforementioned problems, the following investigations and corrective maintenance works were carried out.

Reconnaissance survey

The reconnaissance survey revealed that:

i) The drainage system lacked proper outlet
ii) Tree roots had started to probe through and crack the channel sides. The roots had even undermined the entire drainage channel section at some points.
iii) The stagnated runoff in the drainage system had started to seep into the foundation of the main block of the Agricultural Engineering Department. This seems to have resulted in the differential wetting and, hence, some differential settlement of the building foundation, manifested by some characteristic cracks in the building, at the affected area.
iv) The organic and other litter trapped in the stagnated drainage water had started to putrefy and had become infested with flies, mosquitoes and other pathogenic vectors.

Level/profile survey

A level survey of the bed of the existing channel was carried out to find out the adequacy or otherwise of the channel bed slope. This revealed a slope of 0.059 percent for the portion in front of the departmental building and a slope of 0.069 for the portion at the back. A profile survey of the route of the outlet channel was also carried out. This gave a natural slope of 0.553 percent which was later used as the design slope for the outlet channel (after Linsley and Franzni, 1972).

Removal of interfering vegetation

The teak and eucalyptus trees that distorted and damaged the channel section at various points of the system were removed. This involved the use of various hand held tools that were locally available.

Cleaning of the drainage system

Hand held tools were also used to clean the drainage system. This involved desilting the stagnated water which then became free to drain off.

Outlet channel design

The design of the outlet channel required a knowledge of the runoff discharge being intercepted by the existing system i.e the design runoff discharge (Q-design).

The two main sources of this runoff are the roof surface detention and the runoff from the surrounding watershed. The catchment areas for these two runoff sources are respectively 1077.78m^2 and 2940m^2.

Construction of drainage outlet

The construction involved three main processes. These are:

Cutting the channel section

The channel section was cut by digging and excavation, using hand held tools like diggers, shovel and axe. The construction was done to meet the design specifications given in table 1. See figure I.

Spreading of spoil bank

Luthin (1973) defined spoil bank as the bank of the drainage channel that is covered with the excavated earth from the channel construction. Schwab et al (1981) recommends that for drainage ditches, the spoil bank should be spread until it blends into the adjoining field. This is to permit cultivation near the edge of the ditch. In this construction, the spoil was carried away and used as fill

Table 1:Drainage Channel Dimensions

Discharge	$2.42m^3/_s$
Bottom width	850mm
Bed slope	0.56
Manning	0.040
Depth (d) (flower depth)	430mm
Velocity of flow	0.32m/s
Length of extension	45

Table 2:Runoff Coefficient Versus Type of Catchment Areas

Type of Area	Runoff Coefficient, C
Urban	0.3 – 0.5
Forest	0.05 – 0.2
Commercial and Industrial	0.9
Parks, Farms, Pastures	0.05 – 0.3
Asphalt or Concrete Pavement	0.85

Source: Chow (1959)

materials for the rill erosion lines that were fastly widening into channels.

Lining of the drainage out

This was done by blinding the channel bed with concrete (cast-insitu) and laying 225-mm blocks along the channel sides (see Fig. 2). The reconstructed portions of the existing (or main) drainage system were also similarly lined.

Flood mitigation

The runoff being intercepted from the surrounding catchment area is heavily sedimented. To reduce the sedimentation and mitigate the generated runoff, simple masonry-concrete dykes were constructed across identifiable runoff flow routes. These were used to detain and/or divert some of such flood.

Results and discussion

At the completion of the foregoing corrective maintenance work, the draining of runoffs from two subsequent major rainfalls, were used to assess the success or otherwise of the project. It was observed that the corrective maintenance work resulted in making the channel drain more effectively.

However, small water patches (or pools) still linger in the drainage channel system, together with some sediments. This shows that the system is still not adequately self-cleaning. This continued inadequacy in the performance of the drainage system is attributed to the following.

I. The inadequacy of the channel bed slope (0.069%)
II. The heavy sediment load of the inflowing runoff being generated from the surrounding watershed
III. The obstruction to runoff flow in the drainage system by a water supply pipe system and a booster pump, parts of which are installed within the channel section.

Environmental Assessment Report (EAR)

The potential effects of this corrective maintenance work on the health and socio-economic life of people around the project site were investigated and/or estimated. These were used as environmental impact assessment of the failed drainage system and as an indication of the economic viability of the corrective maintenance work.

These assessments carried out showed that the failed drainage system, if not corrected, could have caused the loss of 15360 man-hours per academic session due to

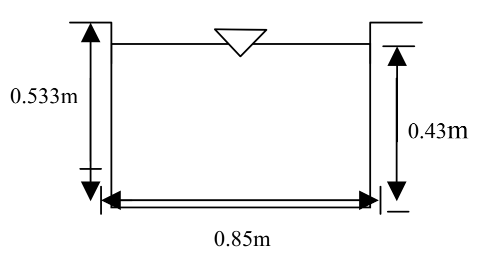

Figure 1. End view of drainage channel (concrete lined)

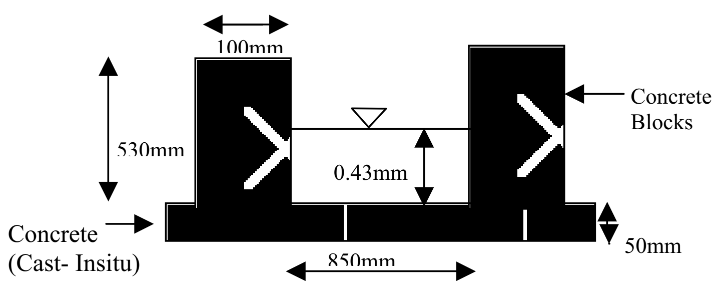

Figure 2. Sectional view of drainage channel

Table 3. A broad indication of the vector-borne diseases naturally transmitted in each zoogeographical region (source: Birley, 1989)

CATEGORY	PREVENTIVE STRATEGY
I Faecal-oral	Improve water quality. Prevent casual use of unimproved sources
II Water-washed	Improve water quality. Improve hygiene. Improve water accessibility
III Water-based	Decrease water contact. Control snails. Improve water quality
a Penetrating skin	
b Ingested	
IV Water-related insect vectors	Improve surface water management. Destroy breeding sites. Decrease human-insect contacts.

malaria and/or typhoid fever disease that could have been suffered by the 32 officers of the Kaduna Polytechnic who stay and work around the deteriorated drainage channel system. The economic analysis carried out, for the corrective maintenance work, gave a benefit/cost ratio of 5:1

The use of physical, health and socio-economic effects of developments, either beneficial or otherwise, to assess the environmental impacts of such developments has been reported by a number of researchers. Abdulmumin and Chukwurah (1999) reported the use of social and health effects to assess the environmental impact of proposed developments. Table 3, by Birley (1989), cited by DFID (2001), shows, among other things, how improved surface water management, destruction of breeding sites and decreased human-insect contacts can prevent water-related insect-borne diseases. Table 4, by WHO (1985), cited by Olowu (1998), indicates, among other cases, that the presence of roots and leaves (especially of aquatic plants), to provide anchorage for mansonia species of flies, can increase transmission of filariasis.

Conclusion and recommendations

Conclusion

It can be concluded from the results and discussion that the failed and deteriorated drainage system would have impacted negatively on the environment and the health of people around the project area, if not corrected, it is also evident from the foregoing that the corrective maintenance work carried out was economically viable.

Recommendation

In the light of the inadequacies highlighted, under the results and discussions and inspite of the corrective work carried, the following recommendations should be given urgent and serious attention by the Kaduna Polytechnic authoritative (the owners of the project site).

i) A regular maintenance schedule, to include the following, should be put in place.

Table 4. Environmental factors that support increased transmission of diseases

Disease	Vector	Environmental And Habitat Factors
Schistosomiasis	Bullinus and other Aquatic snails	Slow-flowing water, increase aquatic vegetation, existence of shallow banks around water bodies
Onchocerciasis	Simulium species	Fast-flowing, well-aerated streams (flow speed 0.5-2.00m/s)
Malaria and Arbo Viruses	Anopheles specie	Varies greatly with species, but generally favoured by increased vegetation at water Body margins, continuous inundation of fields of irrigated crops, over-grown irrigation channels.
Filariasis and Arbo- Viruses	Culex specie	Existence of faecully polluted waters in the Vicinity of human settlements.
Filariasis	Mansonia species	Presence of roots and leaves of aquatic plants to provide anchorage.

a) Regular inspection or monitoring of the system, to take note and take care of any breakages, sedimentation and littering of the system.

b) Removal of all vegetations, for example, trees whose rooting systems tend to or are likely to distort, break or undermine the drainage system.

ii) The lining of the newly constructed 45-m channel outlet which has only been partially carried out should be completed.

iii) The desilting and proper aligning of the immediate downstream culvert, to ensure effective runoff discharge and, hence effective self-cleaning of the drainage system.

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