caused by the slow humification of roots and plant residue.

Biomass and stem T_{SS}. Soil nutrients need to be available for the plants for greater yield. All treatments increased the yield over the unfertilised control without showing an increasing trend over the years. The insignificant differences between the initial and final yields indicated that there are potentials for increasing the yields. The high sugar content of the sorghum stem is an important factor in assessing sorghum quality. The T_{SS} for the treatments in this trial ranged from 14.87% to 22.92%, but the highest T_{SS} was not obtained with the highest biomass yield. The treatment M accounted for the greatest T_{SS}, followed by NPKM with a slight difference. The effect of fertilisers on the sweet sorghum sugar content varies with the environment and gene type, e.g., Holou and Stevens (2012) found that the application of nitro- gen increased the sugar content in sweet sorghum. In contrast, another study (Almodares et al. 2009) observed that nitrogen's application decreased sugar content under the same conditions. In this trial, a relatively higher average value of T_{SS} was observed in the treatments related to manure. The combination of extra manure with inorganics had a negative effect on the T_{SS} in the case of 1.5NPKM, indicating that the amount of FYM in NPKM was proper for the soil type and cultivation of sweet sorghum in this experimental region.

Available potassium and nitrogen. The soil K^+ availability is highest above soil pH of 6.0, and the proper pH range for N availability is 6.0–9.0 (Weil and Brady 2016). The soil pH during the overall experimental period held above 7.4–8.6, which was at the interval of highly available K and N for plants. Thus, the gradual decrease in soil K and N was probably caused by the absorption by sorghum plants while the limited rainfall was not able to leach the soil N and K. The hardly increased biomass yields with years under decreasing available N and K condition requested for a more reasonable inorganic fertiliser application rate.

Available phosphorus. The phosphorus availability generally declines between 7.5 and 8.5 (Weil and Brady 2016). The pH for all treatments varied at 7.4–8.6 during 2008–2018, which indicated the less unavailability of phosphorus to a plant. The steady increase in available phosphorus in the previous years might be caused by the accumulation of P at this pH range. The reason for the subsequent decline in phosphorus for treatments, except for M and NPKM, needs further investigation.

References

1. Almodares A., Jafarinia M., Hadi M.R. The effects of nitrogen fertilizer on chemical compositions in corn and sweet sorghum // American-Eurasian Journal of Agricultural and Environmental Sciences. - 2009. - No 6. - Pp. 441-446.

2. Chang C, Sommerfeldt T.G., Entz T. Soil chemistry after eleven annual applications of cattle feedlot manure. // Journal of Environmental Quality. - 1991. - No. 20. - Pp. 475-480.

УДК 627.8.064.4

STUDING SCOUR HOLE DUE TO PLUNGING JETS

Alsadek Elias Sadek, *Post-graduate student of the Department of Hydraulic Structures of Federal State Budgetary Educational Institution of Higher Education "Russian Timiryazev State Agrarian University", eliasalsadek@gmail.com*

Alipichev Aleksei Yurevich, *DSc (Ed), Associate Professor of the Department of Foreign and Russian languages of Federal State Budgetary Educational Institution of Higher Education "Russian Timiryazev State Agrarian University", alipichev@rgau-msha.ru*

Abstract. *Excess water spilled from reservoirs is often conveyed via one of many spillway types to an energy dissipation structure or area, the structure may be a special stilling basin, or it may be the downstream river bed itself, formulas proposed to date for calculating ultimate scour depth under plunging jets.*

Key words: *scour, erosion process, plunging jet, spillway, energy dissipation.*

Introduction

The prediction of the scour pit is still very imprecise, due to the large number of factors that intervene in the phenomenon: the incident jet form; the energy of the jet/gross head; the specific discharge; the degree of aeration of the jet; the height of water downstream; the rocky matrix of the riverbed and its degree of homogeneity; the degree of alteration and diaclasing of the rock and the possible existence of geological faults; the frequency of operation of the spillway; and the frequency of asymmetric sluice operations [1].

To limit damages as a consequence of scouring, three active measures are feasible: To (1) avoid scour formation completely, (2) design the spillway so that the scour occurs far away from dam foundation and abutments, and (3) limit the scour extent. Since structures for scour control are rather expensive, normally only the two latter are economically viable. Besides elongating as much as possible the impact zone of the jet by an appropriate design of the ski jump, the extent of the scour can be influenced by the measures listed subsequently [2].

Excess water spilled from reservoirs is often conveyed via one of many spillway types to an energy dissipation structure or area. The structure may be a special stilling basin, or it may be the downstream river bed itself. If no stilling basin is provided, scour will occur due to the jet impinging on the river bed.

The extent of the resulting scour depends upon whether the bed consists of rock, cohesive or non-cohesive material. The erosion process is quite complex and depends upon the interaction of hydraulic and morphological factors. If the bed material consists of rock, scour will depend on rock type, weathering, the presence of fissures etc. For this type of material, experience is highly specialized and no general design relations can be given. Scouring can have three major effects:

- the endangering of the stability of the structure itself by structural failure or increased seepage.
- the endangering of the stability of the downstream riverbed and side slopes.
- the formation of a mound of eroded material which can raise the tail water level at the dam.

Jet behavior in a plunge pool

The relations given for jet dimension and velocity can also be used for plunging jets if jet velocity and dimension at impact are taken as initial values. Jet velocity varies with s^{-1} for round jets and with $s^{-1/2}$ for plane jets, where s is the axial distance in the plunge basin from the point of impact.

For practical purposes, the depth of jet penetration may be taken as $20D_u$ for round jets and $80B_u$ for plane jets according to Häusler (1983), where D_u and $2B_u$ represent the jet size at impact. However, these values can vary with the initial jet velocity at the point of impact and the resistance of the river bed against erosion.

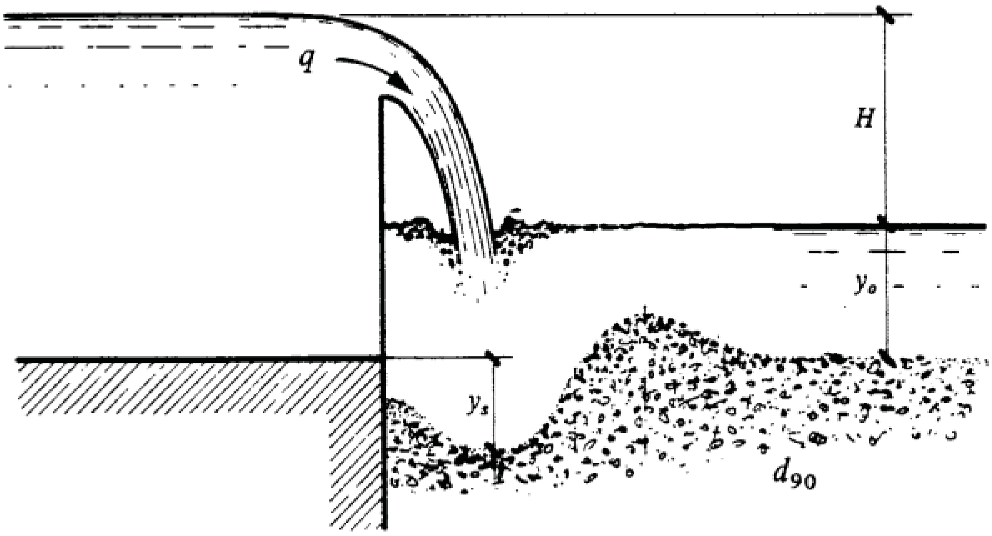

Figure 1 Free overfall jet scour

Aeration of the jet during its flight in air can also affect the jet velocity, but Häusler (1983) assumed that for conventional design values, the core region will persist throughout the drop to the tail water level. He recommends either to ignore aeration or to consider its effect through an appropriate reduction of the jet width at the point of impact.

Scour by plunging jets

Data on scour have generally been obtained from small scale tests with non-cohesive material or from field observations for which the material properties are unspecified.

A selection of available relations shows a variety of forms. Veronese (1937) presented a relationship for plane plunging jets in a flume with *B*=0.5m, discharge *q=0.01* to 0.07 m^2 /s and grain sizes $\bar{d}$=9, 14, 21 and 36 mm:

$$y_s + y_o = 3.68H^{o.225}q^{0.54}\bar{d}^{-0.42} \qquad (1)$$

where $\bar{d}$ is expressed in mm and *H* is the difference in upstream and downstream water-level (Figure 1). Veronese found from a second series of tests that scour varied less than predicted by Equation (1) for $\bar{d}$< 5 mm. This relation is suggested by USBR (1973) as a limiting scour depth, The scour is then given by:

$$y_s + y_o = 1.9H^{o.225}q^{0.54} \qquad (2)$$

Eggenberger (1944) found for an overflow weir type, expressing *d90* in mm:

$$y_s + y_o = 22.88H^{o.5}q^{0.6}\bar{d}_{90}^{-0.40} \qquad (3)$$

Equation (3), predicts very high values of $(y_s + y_o)$, which are probably too high in view of the experimental procedure of removing part of the bed material to accelerate the scouring process.

Damle et al. (1966) evaluated model data and some field data for Indian dams with ski jumps and gave as a best-fit relation in metric units:

$$y_s + y_o = 0.55(qH)^{0.5} \qquad (4)$$

Chian Min Wu (1973) used model and prototype data from dams in Taiwan and found:

$$y_s + y_o = 1.18\, q^{0.51}H^{0.235} \qquad (5)$$

Martins (1975) derived an empirical relation from some prototype observations:

$$y_s + y_o = 1.5q^{0.6}\, Z_2^{0.1} \qquad (6)$$

where Z2 is the difference in elevation between the free surface of the reservoir and the lip of the flip bucket. Mason (1984) and Mason and Arumugam (1985) analysed model and prototype data and gave the following relations:

- Model data

$y_s + y_o = 3.27q^{0.6} H^{0.05} y_o^{0.15} g^{-0.3} d_m^{-0.1}$ (7)

- Prototype data (and model data)

$y_s + y_o = (6.42 - 3.lH^{0.1})q^{(0.6 -0.0033H)} H^{(0.05+0.005H)} y_o^{0.15} g^{-0.3} d_m^{-0.1}$ (8)

The value of d_m was assumed to be 0.25 m for prototype data (d_m is the mean grain size given in meters for these two equations). The relation for model data only is dimensionally correct and satisfies Froude's scaling law. The coefficient of variation was 25% for both model data (47 cases) and for prototype data (26 cases). Outlet types included free overfalls, low level outlets, spillway chute flip buckets and tunnel outlets.

Discussion

Results from the analysis of model and prototype data show great variations in the form of equations and coefficients. Exponents of q vary only from 0.5 to 0.7 whereas the exponents of H vary from 0.05 to 0.5.

A simple theoretical analysis, assuming a plane jet at impact with the downstream water level and a scour depth up to a level for which the maximum jet velocity is equal to some critical velocity for bed material erosion, $U_c \sim (\Delta gd)^{0.5}$, leads to an expression of the form:

$(y_s + y_o) \sim qH^{0.5} d^{-0.5}$ (9)

The exponents are much greater than those from experimental data. Apparently other mechanisms of energy dissipation play a role such as those due to the presence of eroded material in the scour hole. Whittaker and Schleiss (1984) made a comparison of the various relations for a practical case, the Cabora-Bassa dam in Mozambique. This dam has a middle-Level outlet.

The maximum discharge through 8 sluices is 13,100 m^3/s for a reservoir level of 325 m, and the downstream water level is 225 m. The elevation of the lip of the spillway sluices is 244 m. The value of q is estimated to be 275 m^2/s, the downstream water depth is about $y_o = 40m$.

In the model tests, performed at a scale of 1: 75, the movable bed was composed of gravel with $d_{85} = 35mm$, $d_{50} = 28mm$ and $d_{15} = 13mm$. The bed was weakly aggregated with aluminous cement. The corresponding prototype sizes are estimated approximately as *d85* = 2.6 m, *d50* = 2.1 m and *d l5* = 1.0 m. The modeled scour depth for the maximum discharge was 75 m (Quintella and Da Cruz 1982). In February 1982 $(y_s + y_o)$ was measured to be approximately 68 m. The values of scour depth predicted by means of the various formulae are listed in (Table 1).

Table 1

Scour predictions Cabora-Bassa dam

Formula	Equation	Predicted scour depth (m)
Veronese*	1	52
Damle	4	91
Chian Min Wu	5	61
Martins (Z2 =82 m)	6	68
Mason (model)*	7	98
Mason (proto)	8	71
Same for d= 0.25 m	8	87

**The equations of Veronese and Mason (model) have been used at a model scale of 1: 100 to obtain values of q and H in the range of most model experiments. Predicted scour depth has then been translated to prototype scale by multiplying with a factor 100*

Most relations predict a value in the right order of magnitude, although differences between various relations are large, as might be expected [3].

In conclusion: the available relations give an indication of scour to be expected in coarse non-cohesive material or fissured rock. For scour problems related to the construction of high-head dams, detailed studies including model studies, should be performed for each case.

References

1. Pereira, G. M., 2020. Spillway Design - Step by Step. - London, New York, Leiden, Boca Raton: CRC Press.
2. Chanson, H., 2015. Energy Dissipation in Hydraulic Structures. - London, New York, Leiden, Boca Raton: CRC Press.
3. Breusers, H. N. C. R. A. J., 2020. - Hydraulic structures design. 2 ed. - London, New York, Leiden, Boca Raton: CRC Press.

УДК 636

GENETIC DIVERSITY OF THOROUGHBRED HORSES BREEDS IN RUSSIA

***Alrafi Reem**, Post-graduate student of the Department of Animal Breeding, Genetics and Biotechnology of Federal State Budgetary Educational Institution of Higher Education "Russian Timiryazev State Agrarian University", reem.alrafi@mail.ru*

***Abstract:** The aim of the study is to assess and compare the genetic diversity between 9 lines of Thoroughbred horses in Russia, which originated from three eastern ancestors - Godolphin Barb, Burleigh Turk, and Darley Arabian, based on microsatellite markers.*

***Key words:** Allele, Thoroughbred Horses(TB), Microsatellite DNA, Horse genetics.*

Introduction. Thoroughbred (TB) horses have greatly influenced the development of horse breeding around the world. In Russia, the Thoroughbred horse breed has been bred since the second half of the eighteenth century [1]. Detailed information about levels of genetic diversity and patterns of Thoroughbred breed gene structure is very important to meet the requirements of future breeding programs and to formulate effective conservation strategies for Thoroughbred horses.

In recent years, several studies have been conducted to investigate the genetic characteristics of Thoroughbred horses using DNA markers. The aim of our study was to characterize the genetic diversity of Thoroughbred lines based on 17 microsatellite markers (AHT4, AHT5, ASB2, HMS2, HMS3, HMS6, HMS7, HTG10, HTG4, HTG6, HTG7, VHL20, ASB17, ASB23, CA425, HMS1, LEX3), recommended by the International Society for Animal Genetics (ISAG) for identification and pedigree analysis in Thoroughbred horses.

Materials and methods. The genetic diversity of thoroughbred horses was evaluated in the laboratory of the Russian innovative biotechnological company "GORDIZ", by isolating the DNA with the commercial set " Extra Gene TM DNA Prep 200 " (Isogene Laboratory, Moscow, Russia), by conducting a polymerase chain reaction. The results of the studies were processed using generally accepted statistical standard methods [2, 3] and using the POPGENE 1.31 program.