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Development of an Impact Penetrometer for Evaluating Compaction of Littoral Hydrosoils[1]

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ABSTRACT

Hydrosoil texture and density are important factors in controlling the rooting depth and growth of submersed aquatic plants. An impact penetrometer was developed to measure hydrosoil hardness in the littoral zone of a North Carolina-Virginia piedmont reservoir. In using the instrument, a 5-kg driving head is allowed to impact five times against a 3.75-cm diameter wooden dowel rod with 60° piercing cone to exert a pressure of 3 MPa that results in a quantifiable depth of penetration (cm). Comparison of our impact penetrometer with a Soiltest penetrometer yielded a significant inverse relationship (r = -0.933). The impact penetrometer is easy to construct, requires minimal time to operate, and can be used easily by one individual. This instrument may be useful to predict the potential distribution of hydrilla [*Hydrilla verticillata* (L.f.) Royle] and other submersed vascular plants within the littoral zone of large lakes that have varying hydrosoils.

Key words: sediment, compaction, aquatic plant, hydrosoil distribution, littoral zone.

INTRODUCTION

Physical properties of lake hydrosoils are important factors influencing the growth, establishment, and distribution of submersed aquatic plants (Sculthorpe 1967, Hutchinson 1975, McFarland and Barko 1987, Barko et al. 1988). Hydrosoil density has been reported to greatly influence submersed aquatic plant growth responses by influencing rooting depth (Barko and Smart 1986, Barko et al. 1988). The soil penetrometer is currently the only simple instrument available for rapid measurements of hydrosoil compaction *in situ* in the littoral zone of lakes. However, the soil penetrometer is usable only in shallow water < 1 M in depth and does not work effectively in very soft hydrosoils.

The objective of this paper is to describe the construction and use of a simple, hand-held tool for *in situ* measurement of hydrosoil compaction.

MATERIALS AND METHODS

A hydrosoil impact penetrometer was constructed, field tested, and compared with a Soiltest[3] penetrometer (model no. CN-970, Soiltest Inc., Evanston, IL) to determine the compaction of hydrosoils in the littoral zone of Lake Gaston, North Carolina-Virginia. The Soiltest penetrometer gives readings in megapascals (MPa) of pressure required to push a 3.75-cm diameter, 60°-slope cone to a depth of 15 cm into the soil (Greacen et al. 1969). The hydrosoil impact penetrometer (Figure 1) measures the maximum depth of penetration (cm) when a known pressure is applied.

When operating the hydrosoil impact penetrometer, a 5-kg iron driver is allowed to free-fall a distance of 50 cm to impact an iron head on a 2.5-cm diameter iron rod. Each impact produces 0.6 MPa of pressure and drives a 175-cm x 3.75-cm diameter wooden dowel rod into the hydrosoil. The wooden dowel has a 60° sloped steel cone on the end and is marked in 1-cm increments from 0 to 50 cm on the opposite end to measure penetration. The wooden dowel is placed into a section of PVC pipe (120-cm length x 4-cm inside diameter), which is marked at 1 M for a water depth reference when in use. A square section of plexiglass (22-cm diameter x 0.6-cm thick) is attached at the lower end of the PVC pipe by PVC retaining rings and attached with PVC glue (methylene chloride) to hold the plexiglass in place. The plexiglass prevents the PVC pipe from penetrating the hydrosoil. The PVC pipe section provides a mechanism for holding the instrument stationary when in use, and also allows the wooden dowel to penetrate with no interference.

Hydrosoil compaction measurements were taken at the 1 M depth at 175 locations around the periphery of Lake Gaston (Coley 1993). Hydrosoil compaction was measured at these locations with the Soiltest penetrometer by pushing the rod into the hydrosoil and recording the reading (MPa) on the instrument dial, and by using the hydrosoil impact penetrometer, where a penetration reading (cm) was read on the wooden dowel after five impacts of the driving head.

Numbers recorded for both instruments were averages of 3 separate readings at each sampling location. Data were compared by regressing the pressure (MPa) applied with the Soiltest penetrometer against the depth of penetration (cm) measured on the impact penetrometer.

RESULTS AND DISCUSSION

Regression analysis of the 175 pairs of measurements showed an inverse relationship (r= -0.933) (Figure 2). If the hydrosoil was compact, great force was required to penetrate it with a cone; hence, the hydrosoil impact penetrometer

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[3] The use of trade names does not imply endorsement of the products named, nor criticism of similar ones not mentioned.

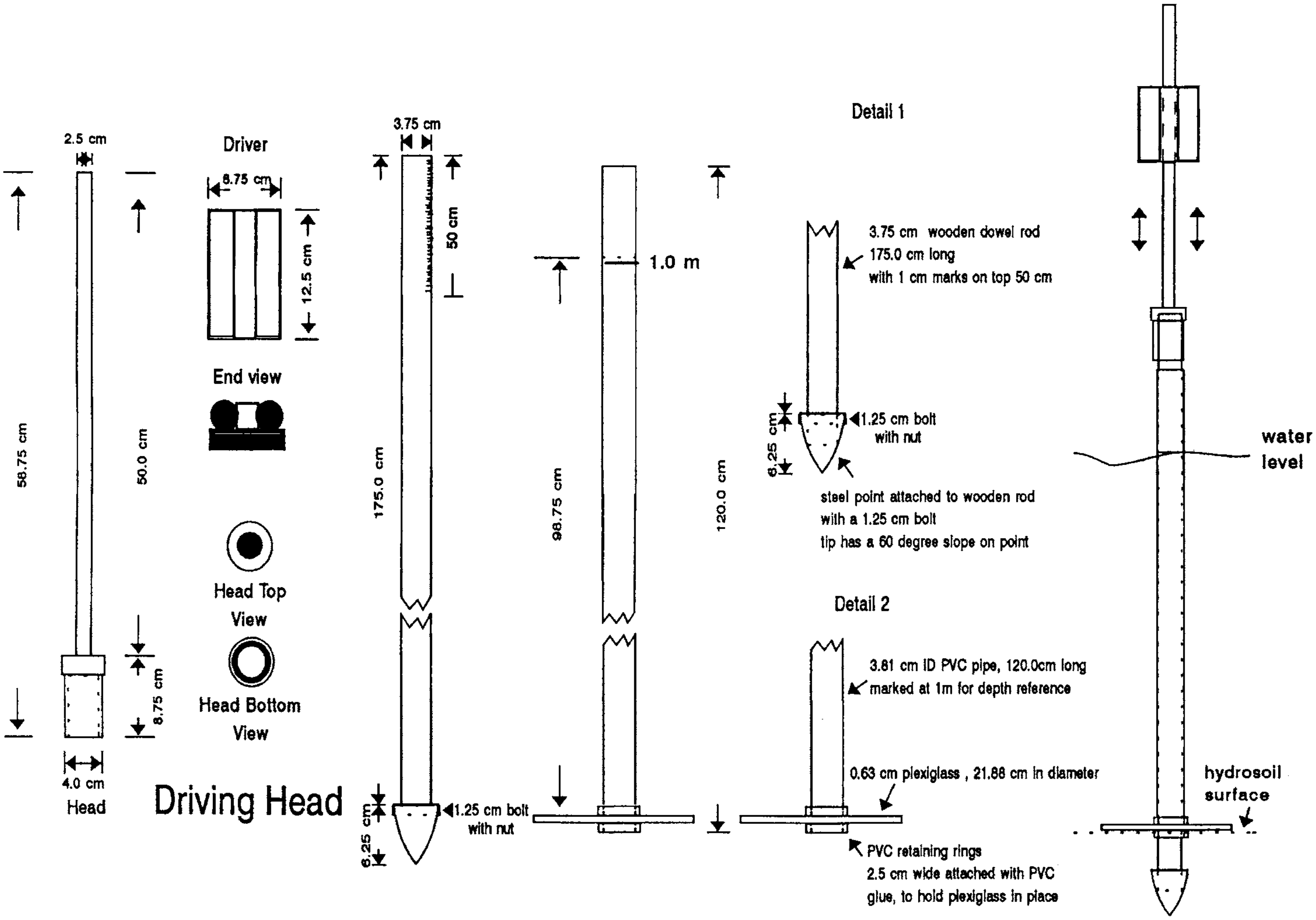

Figure 1: Details of construction of an impact penetrometer for measuring hydrosoil compaction in the littoral zone of a North Carolina-Virginia piedmont reservoir, Lake Gaston.

showed low penetration. If the hydrosoil was soft, high penetration would correspond to a low MPa reading. Data for the regression of Soiltest penetrometer against the impact penetrometer (Figure 2) show considerable variability in the 1 to 3 MPa range. This variability was unavoidable and not entirely unexpected. The primary cause is the limitation of the Soiltest penetrometer, which is designed to operate in more compact, terrestrial soils, rather than the soft, flocculent hydrosoils.

Field observations at Lake Gaston showed that denser, more robust growth of monoecious hydrilla and other plants occurred on the softer hydrosoils (authors unpublished data, 1992-1993). As hydrosoils increased in compaction, growth generally was poorer. In other studies, growth of monoecious hydrilla decreased as the hydrosoil bulk density and compaction increased (Coley 1993).

The hydrosoil impact penetrometer is a simple field instrument that requires little time to operate and can be used by one individual. It could be used to relate hydrosoil hardness to the growth response of hydrilla and other aquatic plants. It also shows potential use in predicting the

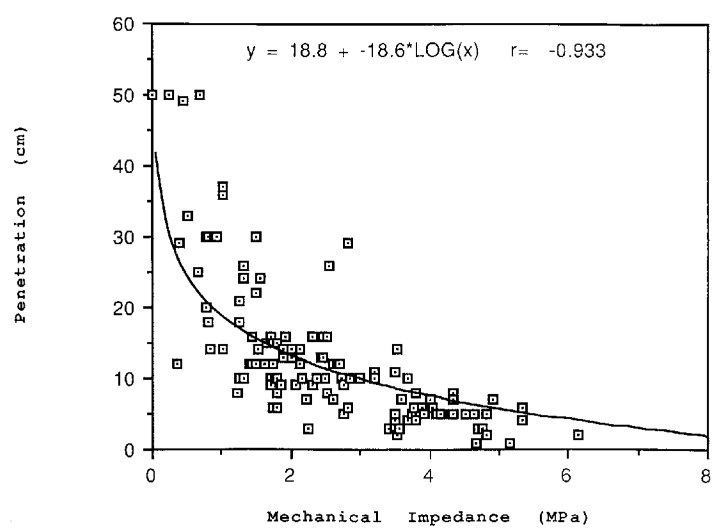

Figure 2: Regression analysis of the Soiltest penetrometer measurements (MPa of pressure) against the hydrosoil impact penetrometer measurements (cm of penetration) on Lake Gaston littoral zone hydrosoils.

extent of colonization by hydrilla and other aquatic plants in impoundments and lakes which contain a diverse variety of hydrosoils within their littoral zones. The impact penetrometer, by having minimal hydrosoil depth measurement limitations, would be more advantageous to use in measuring compaction of soft, flocculent hydrosoils that often are found in southern lakes and reservoirs. This instrument could be adapted for use in deeper areas by increasing the length of the vertical rod and casing. This however, would require additional instrument calibration as the difference in weight of the larger rod would affect the depth of penetration into the hydrosoil. Future research and instrument testing are needed to delineate more clearly the interrelationships of hydrosoil compaction, bulk density, and texture on growth and distribution of hydrilla and other aquatic plants within Lake Gaston and other water bodies.

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