INTRODUCTION

The study of the initial pedogenesis on dated surfaces is a widely used methodological approach, which makes it possible to acquire information on changes in the soil properties with time at the early development stages of the soil profile [1, 7, 26, 41, 42] and predict their further evolution.

In a recent generalizing work of Abakumov [1], the accumulation and transformation of organic matter are considered the main processes of the initial pedogenesis in all natural zones.

For the Northern Caspian clay semidesert with the predominance of solonetzic complex in the soil cover, Gennadiyev studied the development of soils over time [7], but his studies dealt with zonal soils or their analogs and covered long time intervals measured in centuries and millennia.

This paper presents the results of studies of soils formed on the bottom of an artificial mesodepression in a clay semidesert within 30 years. Under such conditions, initial pedogenesis on the bottoms of artificial hollows has not been studied, in spite of the undoubted theoretical and applied importance of such investigations. Snow and melt water accumulate in natural and anthropogenic mesodepressions, which results in an increase in the reserves of productive water, the leaching of soluble salts, and, in some cases, the formation of fresh groundwater lenses. Favorable conditions are thus created for the spontaneous propagation and development of herbaceous, shrubby, and woody plants in the bottoms of artificial hollows. The development of a soil profile is accompanied by the depletion of the clay fraction from the upper W horizon, presumably due to the predominant removal of smectite minerals. In the upper W horizon, transformations of layered aluminosilicates takes place: it involves the formation of illites from smectites and from smectitic layers in illite–smectite mixed-layered minerals and partial vermiculitization of chlorites. The technology used upon the excavation of the hollow can be recommended for growing woody–shrubby plants on soils of the solonetzic complex in the clay semidesert during a relatively short time period.

Keywords: initial pedogenesis, clay semidesert, mesodepression bottom, profile differentiation, clay minerals, illitization, vermiculitization

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northern Caspian Lowland, are described in detail in numerous publications [3, 5, 28]. In the soil cover of the territory, a solonetzic complex is predominant, which consists of solonchakous solonetzes on microrelief heights, meadow-chestnut soils in microdepressions (pits), and light chestnut soils on their slopes. Meadow-chestnut soils prevail in natural mesodepressions (hollows) [28].

An artificial mesodepression 30 × 40 m in size and 3 m in depth was mainly confined to the plot with complex soil cover. It had been planned to create a pond with water fed from a special canal, but the hollow was filled only once with water in 1980.

Initially, the soil was unsuitable for plants: the entire fertile soil layer and a sediment layer 3 m thick were removed during the digging of the pond, and mother rock depleted in nutrients and containing some toxic soluble salts was exposed on the surface. However, the water conditions of bottom of the pond-hollow were favorable for the development of woody and shrubby plants. The close arboretum of the station, which collected 120 species of acclimatized trees and shrubs, also contributed. Already by 1982, the bottom surface was occupied not only by common reed (Phragmites australis Trin. ex Steud.), but also by some tree and shrub species [35]. Self-sown sharp-fruited oleaster (Elaeagnus oxycarpa Schlecht.), black poplar (Populus nigra L.), white poplar (P. alba L.), Caspian willow (Salix caspica Pall.), and other species also appeared. At the same time, frequent and lasting overmoistening of the lowest areas corrected the over-growing of the bottom. Species tolerant to long-term flooding or those grown on less flooded elevations persisted.

Intensive overgrowth of the pond hollow began in 1985–1986 from the self-seeding of trees and shrubs, whose seeds arrived from plants grown at about 300 m, but most of these self-sown plants usually died because of flooding in the first or second year. In 1993, 29 species of woody and shrubby plants had survived. On the bottom of the pond–hollow, sharp–fruited oleaster was the most prevalent species, which formed a fragmentary canopy 5–6 m high, although many plants had dry tops or even died. The predominance of sharp-fruited oleaster is related to its wide ecological amplitude and good adaptability to changing environmental conditions [24]. It was revealed that the natural complex on the bottom of the pond–hollow developed as tugais (intrazonal formations of the desert zone composed of riverine woody and shrubby plants in combination with wetland groups [22]).

The peculiarity of the natural–anthropogenic complex on the bottom of the pond–hollow is determined by the flooding conditions and significant variation of the groundwater table.

About 20 species survived to 2011, among which sharp–fruited oleaster, black poplar, and Caspian willow are predominant; golden currant (Ribes aureum Pursh), common barbery (Berberis vulgaris L.), and Tatarian honeysuckle (Lonicer tatarica L.) grow on the slopes. On the slope, white poplar formed a cloned, different-aged plantation, which occupies about 50% of the plot area. The mean height of curtains is 13 m; the height of mother trees is 22 m. Oleaster and willow occupy 10% of the plot, and 30% of the area consists of windows with solitary self-sown white and black poplar trees 1 to 3 years old.

The ground cover of the bottom consists of a weed–wetland plant association with the participation of chee reedgrass (Calamagrostis epigeios L.), common reed (Phragmites australis Trin. ex Steud.), and lofty water-horehound (Lycopus exaltatus L. fil.). The intrazonal character of the developing biogeocenoses, which we revealed earlier, remains, as well as their quasi–tugai appearance [35].

OBJECTS AND METHODS

The objects of study were samples taken from the genetic horizons of three profiles established on the flat bottom of the pond–hollow (Fig. 1). The parent rock has a clay loamy texture, loose angular blocky structure, and pale-brown color; it strongly effervesces with HCl and contains interlayers enriched with gypsum druses.

All three studied profiles had similar structures with some variations in horizon depths. This allowed the samples from the same horizons to be considered as belonging to the same populations and to be processed statistically [11]. A sample from the C4ca,cs horizon was taken in only one profile. In a profile, drilling was performed to the groundwater table, which occurred at a depth of 3.8 m, and a water sample was also taken to be analyzed. Litter samples were taken in four replicates from an area 0.5 × 0.5 m in size; litter mass, total ash, and certain chemical elements were determined.

In soil samples, pHwater was determined by potentiometry on a Mettler Toledo Seven Go Pro instrument. The contents of C and N in the A1 horizon were studied on a Vario–EL III V4-01 Elementar Analyse System (Elementar Analysensysteme GmbH, Germany). Water extracts and groundwater were analyzed by conventional procedures [6], but the sum of K and Na was estimated from the difference between the total anions and (Ca + Mg) so that the results were comparable to the previous data obtained for the soils of the Dzhanybek Station. Exchangeable bases were determined in a 1 M NH₄Cl extract by the Pfeffer method. The concentrations of K and Na in ammonium chloride extract were determined by photometry on a PFP-7 instrument; Ca and Mg were determined by AAS on a Unicam 929 AA spectrophotometer. The ash content was determined by incineration at 525°C [9]. The ash was dissolved in aqua regia under heating in a microwave oven [16]. Chemical elements were determined by ICP–MS on an Agilent 7500A ICP–MS instrument.