[10–12]. Data on the historical quality of HM of the observed territory's natural resources is very useful from a realistic point of view, because it offers knowledge on the resilience of habitats of relation to future temperature and geochemical shifts due to global and regional anthropogenic impacts. In fact, these data offer an ability to forecast food, animal and human epidemiological diseases [13–17]. Intake of HM into plants is influenced by factors such as plant types, soil type, concentration, soil composition, soil pH, particle size distribution, organic matter content, cation absorption ability in soil, and the presence of anthropogenic pollution sources. In addition, the distribution of HM within the plant depends on the physiological functions performed by the plant's various organs, their morphological structure and the physiological functions performed by the chemical elements [18–21]. Thus, the current selective absorption by plants of chemical elements should be viewed more broadly: not only as a collection of elements essential for metabolism, but also as an opposition to element entry. Selective absorption rates are numerous in a plant organism: from less alert (at the border of the root environment) to more rigid (in terrestrial organs, in particular at the border of stem seed (fruit). Chemical elements enter the plant in favorable proportions for life-activity due to selective absorption [22–24].

The purpose of the research was to define the level of HM accumulation by various types of wild vegetation of the East Kazakhstan region.

2. Materials and methods

East Kazakhstan region is located in the eastern part of Kazakhstan, on the border with Russia and China (Fig. 1a).

This area covers a very large variety of geological and climatic areas from the Altai in the east and eastern edges of the Kazakh steppes in the west of the region [4,25]. The flora and fauna of East Kazakhstan is amazing and diverse (Fig. 1b). About 90% of the republic's forest wealth is concentrated in the region. The study area's vegetation cover is characterized by considerable diversity and is typical of steppe, and partially desert-steppe zone [10,14,26–28].

Steppe and desert-steppe-zone typical plants were investigated in the research zonal; a total of 100 plant samples were analyzed, 18 species from 6 families. Samples of all available genetic horizons of the soil segment were taken for analyses. Standard methods were used to determine the composition of all the soil samples (pH, humus, CO_2 carbonates, distribution of particle size) [4,10]. The content of HM in the studied soils was determined on a KFK-3 device using the photocolorimetric dithizone method based on measurement of an optical density of the painted extract according to G.Ya.Rinkis's prescription [29–31]. The reproducibility of the method is ±4.2%, sensitivity of a method is 0.01 mkg/ml. The selection of fractions of heavy metals was performed by the method of parallel extraction. All analytical material is processed by the method of mathematical analysis and mathematical statistics in soil science according to the method of E.A. Dmitriev [24,30].

3. Results and discussions

The features of absorption of chemical elements by vegetation, described in the scientific literature [18,22,32–40], are mainly manifested in the study area.

The distribution of HM in vegetation has the following descending series: Mn > Zn > Cu > Pb > Co > Cd (Table 1). Wild vegetation of the studied region has a significant amount of lead than cobalt. Characteristic is a significant variation in the content of HM in wild plants. The maximum variation of HM occurs in cadmium (72%) and manganese (62%), the minimum variation in zinc (25%).

The significant variability of metals in plants is due to their genotypic specificity, their geochemical and ecological environment. To assess the geochemistry and physiological role of each chemical element, it is important to know not only its content, but also the intensity of utilization of this element by the plant [35]. As shown in Table 1 according to the value of coefficient of biological absorption (CBA), which indicates how many times the element content in plant ash is more than in the lithosphere, Cu, Co are elements of the average biological capture and weak accumulation in plants; Zn, Mn, Pb – refers to the elements of strong biological accumulation and Cd - to the elements of energetic biological accumulation (in calculating the CBA, the average content of elements in the crust was calculated by A.P. Vinogradov [34,35]).

According to the CBA level, the elements under study are in the following descending order:

Cd (45.9) > Zn (2.1) > Mn (1.2) > Pb (1.1) > Co (0.9) > Cu (0.6).

Data on the ecological regularity of the accumulation of heavy metals by the same plant species on different types of soils are shown in Fig. 2.

The results of this study show that the same plant species accumulates different amounts of heavy metals on different types of soils [12,13,41–43]. So, for example, the content of the heavy metals under study changes as follows: copper – 1.1–3.5 times, zinc – 1.1–3.2 times, manganese – 1.1–2.5 times, cobalt 1.1–2.0 times, lead – 1.1–3.3 times, cadmium – 1.1–6.3 times. It was revealed that the content of heavy metals in the families of plants of the studied area depends on both their content in the soil and the situation with the mineral nutrition characteristic of the given type of soil.

Fig. 1. East Kazakhstan: a- a map of Kazakhstan regions, East Kazakhstan region is shown by red color; b- picturesque vegetation of the East Kazakhstan. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)