Soil Free-living Nematodes as Indicators of Soil Contamination in Central Asian Industrial Areas

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Abstract

The effect of industrial pollution on soil free-living nematode communities was investigated in the Almalyk and Angren industrial areas, Uzbekistan. Soil samples were collected from the upper soil layers in downwind directions from the emission sources of the industrial sites. Soil nematode communities were exposed to heavy metal influence both directly and through soil property changes. The nematode communities and their trophic diversity, sex structure, and taxon composition were found to be affected by the variety and concentration of chemical elements. Pollution effect on the density and biomass of soil free-living nematodes was found to be greatest at the pollution source, with fungivores and plant parasites dominant at the upper and deeper soil layers next to the pollution source in the Almalyk industrial area, while in the Angren industrial area, the fungivores were dominant next to the pollution source, with plant-parasites being least abundant at the same sites. The sex ratio of nematode communities was found to be dependent on heavy-metal pollution levels, with the juveniles being the most sensitive nematode group. The maturity and modified maturity indices, reflecting the degree of disturbance in the soil ecosystem, were found to be the most sensitive indices in both observed areas.

Introduction

Soil free-living nematode communities and their structural changes have been found to be one of the best biological tools for assessing soil disturbances, including heavy-metal pollution (Bongers et al., 2001; Georgieva et al., 2002). Due to their sensitivity to changes in the soil ecosystem and their ability to reflect differences between undisturbed and human-impacted environments, the free-living nematodes are considered to be useful and inexpensive indicators for ecological research (Porazinska et al., 1999). Previous investigations showed that density, biomass, trophic structure, species diversity, and sex ratio of soil free-living nematode communities were sensitive to anthropogenic changes in soil ecosystems (Pen-Mouratov et al., 2008; Yeates, 2003). Various ecological indices such as Wasilewska, nematode channel ratio, Shannon–Weaver diversity, richness, and maturity, were accepted in numerous research studies as useful tools for the assessment of changes occurring in nematode assemblages undergoing environmental disturbances (Bongers, 1990; Wasilewska, 1997; Yeates and Bird, 1994). To assess the effects of human activity on the environment, the current research was conducted in the Almalyk and Angren industrial areas, which are among the largest industrial complexes in Uzbekistan, and which include mining, a metallurgical complex, a coal-fueled power plant, and resin industries.

Material and Methods

The study sites were situated at the southeast part of the Tashkent region of the Republic of Uzbekistan: 1) in the Almalyk Mining and Metallurgical Complex area (40º 85'N and 69º 69'E) near the city of Almalyk; and 2) in the Angren industrial area, which includes coal mining, a coal-fueled power plant, and resin industries, and is located on the upper side of the Akhangaran River Valley, near the city of Angren (41º01'N–70º 09'E). Four sampling stations in the Almalyk area and six sampling stations in the Angren area downwind a deposition gradient from the main source of pollution, were selected. Samples were stored at 4^{o}C, then sieved and analyzed for soil free-living nematode communities: soil properties, including soil moisture, organic matter, soil pH, soil cations (Ca^{2+}, Na^{+} and K^{+}), total soluble nitrogen and metal concentrations.

Results and Discussion

The results obtained in this study showed a strong effect of industrial pollution on soil nematode communities and their habitats, with nematode density decreasing at the source of pollution. Both nematode density and trophic diversity were found to be strongly dependent on affected by environmental disturbance. In the Almalyk industrial area, plant parasites, followed by fungi-feeding nematodes, were the most dominant trophic groups at the pollution source, while with distance, their dominance was replaced by bacteria-feeding and omnivore-predator nematodes. However, in the Angren industrial site, the fungivore nematodes were regarded as insensitive to most pollutants, in contrast to other nematode trophic groups. Plant-parasite nematode density was lowest at the pollution source; this is the exact opposite of data obtained for the Almalyk area. In contrast to other nematode trophic groups, the plant-parasite nematode community was predominantly negatively correlated with the observed chemical elements such as Cu, Zn, Ga, Rb, Zr, Nb, Pb, Th, and U. Therefore, in the present case, both the direct impact

of pollution on the plant-parasite nematode community and the indirect negative influence through a vegetation-density decrease, must be considered. The omnivore-predator nematodes belonging to K-strategists, in agreement with numerous publications (e.g., Georgieva et al., 2002), were more numerous in unindustrialized areas, i.e., they preferred eco-friendly surroundings to metal-contaminated areas. Our data indicate that 82% of the observed nematode species were affected by either soil properties or metal concentration. Along with nematode abundance, trophic structure, and species diversity of the nematode community, nematode biomass and sex ratio demonstrated significant changes along the emission gradient, with juveniles being the most sensitive to industrial pollution.

Of all the widely used ecological indices applied in the present researches, the maturity index was more sensitive to environmental disturbances (Yeates et al., 1999) caused by industrial pollution in both industrial areas. The Wasilewska index, describing the relative balance of positive-to-negative impacts of nematodes on primary productivity or stage of decomposition (Neher and Darby, 2005), showed the negative impact of nematodes on primary production in the Angren industrial area in contrast to the other sampling sites. The nematode channel ratio (NCR) (Moore and Hunt, 1988) indicated that the bacterial-based decomposition process was dominant in soils exposed to industrial pollution in the Angren area.

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