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Aluminium level in soil, fodders, cereals and some vegetables and fruits proceeded from aluminium industry areas

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Abstract

Aluminium, the third most abundant element in the soil is ubiquitous in the biosphere being found in all forms of life on Earth. The goal of the study is to evaluate the contaminant potential of primary and secondary aluminium industry on soil, fodders, and plants for human consumption. The study was carried out in alumina plant surrounding areas and in primary and secondary aluminium industry areas. There was sampled soil from 0.5-1, 2.5-3 and 7-10 km (in alumina plant surrounding areas) and from 0.1, 0.5-1, 2-3, 6.5-7 and 9-10 km (in primary and secondary aluminium industry areas).At the same distance were drawned fodders and feeds of vegetable origine for human conumption. Conclusions: aluminium concentrations in plants for animal and human consumption in aluminium areas are inconstantly, but inverse correlated to the distance away the factories; aluminium level is higher than in not exposed to contamination risk areas; aluminium concentrations are the highest in the underground parts of plants (tuber, bulb, root); alumina industry has a higher contamination potential than aluminium primary and secondary industry emphasized by higher aluminium concentrations in vegetables.

Keywords: aluminium, plants, soil, industry areas

1. Introduction

Aluminium, the third most abundant element in the soil (Alfrey, 1986) is ubiquitous in the biosphere being found in all forms of life on Earth (Gauthier, 1997; Exley, 2003). Its concentration in soils varies widely, depending on soil type, depth and vegetation types (ATSDR, 1999). In spite of its abundance, there is no evidence to support an essential function for aluminium in humans and there is only limited information to suggest any essential role in any other form of life (Exley, 2003).

Aluminium toxicity is a major problem in agriculture, affecting perhaps as much as 40% of arable soils in the world (Flaten, 1996).

It should be noted, however, that the aluminium is assimilate by the plants only in acid pH conditions, when the metal became bioavailable. Among acid tolerant plants, tea (Lewis 1989 quoted by ATSDR, 1999) and some fern species (Ghergariu, 1996) accumulate high quantities of aluminium.

The goal of the study is to evaluate the contaminant potential of primary and secondary aluminium industry on soil, fodders, and plants for human consumption.

The objectives were to evaluate:

- pH values and aluminium concentration in soil samples drawned from alumina, primary and secondary aluminium surrounding areas;
- aluminium contamination level in fodders and plants for human consumption.

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2. Materials and method

The study was carried out in alumina plant surrounding areas and in primary and secondary aluminium industry areas.

There was sampled soil from 0.5-1, 2.5-3 and 7-10km (in alumina plant surrounding areas) and from 0.1, 0.5-1, 2-3, 6.5-7 and 9-10km (in primary and secondary aluminium industry areas).

From the same distances were drawned fodders and plants for human consumption as follows: Graminaceae hay, maize (upper part and grains), potato (tuber), carrot (root), celery (root), onion (bulb), spinach (leaves), pepper (fruit) (in alumina plant surrounding area) and spontaneous vegetation from pasture, alfalfa (upper part and root), alfalfa hay, wheat-early vegetation period (upper part, root, grains), barley (early vegetation period), rye (early vegetation period, hay), maize (grains, haulum), oats (grains), carrot (root), parsley (leaves, root), pepper, potato, onion (leaves, bulb), garlic, cabage, apple, quince (in primary and secondary aluminium industry surrounding area).

The technique involved for aluminium determination in soil and plants was the atomic absorption spectrophotometry by Analyst 100 PERKIN ELMER with graphite and flame oven.

Soil pH values was determined by pH-meter.

3. Results and discussion

The aluminium concentration in soil and soils pH values are presented in table 1 (alumina plant surrounding area) and table 2 (primary and secondary aluminium industry surrounding area).

Table 1. Aluminium concentration (mg/kg DM) and pH values in soil in alumina plant surrounding area

Specification	Distance from the factory - km		
	Until 1	2 - 3	7 – 10
Aluminium	4824	3162	4100
pH	6.91	6.61	7.17

Table 2. Aluminium concentration (mg/kg DM) and pH values in soil in primary and secondary aluminum industry surrounding area

Specification	Distance from the factories - km					
	50 m**	100 m*	0.5–1 km*	2-3 km*	6.5-7 km*	10 km **
Aluminium	51528±519.54	151196±842.276	14628±277.538	9459.682±14.561	9039.107±561.62	1794.823±158.13
pH	7.05	7.35	8.23	6.72	7.45	7.20

* away from primary aluminium industry surrounding area
** away from secondary aluminium industry surrounding area.

It was evidently observed the significant decrease of aluminium concentration according as distance away the factories increase.

At same distance away the factories, aluminium concentration was higher in soil samples provided from alumina plant surrounding areas.

The references concerning aluminium level in soil are contradictory: Sorensen et al, 1974 found 160-600 mg Al/kg soil in unexposed to contamination risk areas, Shacklette and Boerngen, 1995, quoted in a WHO study from year 1997 reported 700 – 100 000 mg Al/kg, Lindsay et al, 1997, quoted in an EPA study from year 2000 sustained that the usual soil aluminium content is between 1 – 30% (10 000 – 30 000 mg Al/kg), Greger, 1993, also sustained that soil containes a variable quantity with a mean value of 7.1% aluminium (7100 mg/kg).

Table 3. Aluminium concentration in fodder and plants for human consumption in alumina plant surrounding area (mg/g DM)

Specification	Distance from the factory - km		
	Until 1	2 - 3	7 – 10
Graminaceae hay	0.0177	0.0320	0.4473
Maize (upper part)	0.0308	0.426	0.0265
Maize (grains)	0.0479	0.1139	0.0869
Potato (tuber)	12.0707	12.8645	10.3130
Carrot (root)	2.6262	2.6261	2.6832
Onion (bulb)	11.2671	9.6863	7.9237
Celery (root)	7.1060	2.0001	6.2840
Spinach (leaves)	2.8564	1.3114	1.2642
Pepper (fruit)	7.9542	6.8200	1.0367

Table 4. Aluminium concentration in fodder and plants for human consumption in primary and secondary and secondary aluminium industruy surrounding areas (mg/g DM)

Specification		Distance from the factory - km		
		0.1 – 1 km	2 – 3 km	7 – 10 km
1		2	3	4
Spontaneous vegetation		0.266	0.258	0.374
Alfalfa	green mass	0.317	0.233	0.128
	hay	0.138	0.155	0.137
Wheat grains		0.056	0.036	0.034
Barley grains		0.030	0.032	0.019
Rye	green	-	0.162	-
	hay	-	0.187	-
Maize	grain	0.058	0.07	0.06
	haulum	0.401	0.168	0.162
Oat grains		0.035	0.03	0.03
Carrot root		0.831	-	0.274
Parsley	leaves	0.563	-	0.201
	root	0.607	-	0.270
Pepper		0.0370	-	0.035
Potato		-	-	0.082
Onion	leaves	-	-	0.016
	bulb	-	-	0.063
Garlic		-	-	0.022
Cabage		-	0.053	0.034
Apple		-	-	0.0087
Quince		-	-	0.057

N.B. Aluminium concentration was determined after dust washing from the plants, therefore the values represents aluminium level reached through radicular absorption and transfoliar passage.

Comparative to Sorensen et al, 1974, data, soil contamination was evidently. Comparative to other references aluminium level was in admitted limits, but aluminium level decrease according as distance away the factories increase, that meaning the higher levels recorded are the consequences of the industrial contamination.

pH values were circumneutral in all soil samples, even slightly alcaline at 500-700 m away the factory in primary aluminium surrounding area.

The aluminium concentration in fodder and plants for human consumption are summarized in table 3 (alumina plant surrounding areas) and table (primary and secondary aluminium industry surrounding areas).

In wheat husks sampled at 1 km away the factory aluminium concentration was 3.2 time higher than those found in areas unexposed to contamination risk (0.012 mg/g DM – Greger et al, 1985, quoted by Greger, 1993).

Generally aluminium level decrease according as the distance away the factory increase.

The study in primary and secondary aluminium industry areas pointed out that in fodders as spontaneous vegetation from the pasture, alfalfa (green mass and hay), rye, maize / haulum the aluminium concentration exceeded the values mentioned by European Commission for Consumer Protection as normal for fodders, respectively, under 100 ppm.

Aluminium concentrtion evidently decreased according as the distance away the factory increased in alfalfa (green mass) and maize – haulum.

In grains (wheat, barley, maize, oat) aluminium concentrations ranged in limits reported by Vogt and Jaakola, 1978, Schenkel and Kluber, 1987, quoted by European Commission for Consumer Protection (***, 2003), respectively 5 – 68 ppm/DM.

Aluminium concentration slightly decreased according as the distance from the aluminium source increased in wheat and barley and remained aproximatively at the same values in maize and oat.

In vegetables, the highest aluminium concentrations were recorded in carrots and parsley. The concentrations decreased according as the distance from the factories decreased.

Aluminium concentrations in pepper is not influenced by the distance away the factories, but is higher than those raported in different vegetables, in areas not exposed to contamination risk (0.035 – 0.037 / 0.00011 – 0.0002 mg/g)(Greger et al, 1985, quoted by Greger, 1993; Pennington et Jones, 1988, quoted by Greger, 1993; ***, 2003).

In cabbage aluminium concentration exceed the concentration found in areas not exposed to contamination risk (0.034 – 0.053 / 0.00001 – 0.0002 mg/g) (Greger et al, 1985, quoted by Greger, 1993, Pennington et Jones, 1988, quoted by Greger, 1993; ***, 2003).

Potatoes contained, also, higher aluminium concentration comparative to those from areas not exposed to contamination risk (0.082/0.00078 mg/g) (***, 2003), and at the same distance away the factories higher than in peppers, potatoes, onion and garlic.

The analyse of aluminium concentrations in vegetable pointed out the higher aluminium accumulation in underground part of the plants.

It seems there is a difference between species of friuts regarding aluminium accumulation (in quince higher aluminium concentration as in apples). In analized fruits (apples and quinces) aluminium concentrations were higher than in fruits from areas not exposed to contamination risk (0.0087 – 0.057 / 0.0005 – 0.004 mg/g) (Pennington et Jones, 1988, quoted by Greger, 1993, Sorensen et al, 1974, quoted by Greger, 1993).

Despite the fact that pH values of the soil was circumneutral, aluminium concentrations excedeed the concentrations reported in areas not exposed to contamination risk. That means, aluminium level is due to aluminium aerosol diffusion too.

The study pointed out the absence of a constant correlation between aluminium concentrations in soil and plants in both studied industrial areas.

However, in all vegetables, aluminium concentrations, at the same distance away the factories, were higher in alumina plant areas.

4. Conclusion

- aluminium concentration in plants for animal and human consumption in aluminium areas are inconstantly but inverse correlated to the distance away the factories;
- aluminium level is higher than in not exposed to contamination risk areas;
- aluminium concentrations are the highest in the underground parts of plants (tuber, bulb, root):
- alumina industry has a higher contamination potential than aluminium primary and secondary industry emphasized by higher aluminium concentrations in vegetables.

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