Bull. Environ. Contam. Toxicol. (2000) 65:153–160

DOI: 10.1007/s001280000109

Bulletin of Environmental Contamination and Toxicology

Use of Recultivated Electrofilter Ash Dumping Areas for Sheep Breeding

U. Pestevšek,[1] P. Juntes,[2] M. Pogačnik,[2] D.-Z. Doganoc[3]

[1] Institute for Hygiene and Pathology of Animal Nutrition, University of Ljubljana, Veterinary Faculty, Gerbičeva 60, SI-1115 Ljubljana, p.p. 3425, Slovenia
[2] Institute for Pathology, Forensic and Administrative Veterinary Medicine, Gerbičeva 60, SI-1115 Ljubljana, p.p. 3425, Slovenia
[3] Institute for Food Hygiene and Bromathology, Gerbičeva 60, SI-1115 Ljubljana, p.p. 3425, Slovenia

Received: 22 January 2000/Accepted: 12 May 2000

The dumping areas of electrofilter ash, the side product of power plants using coal as a fuel, are a great ecological problem. They are often hard to recultivate and represent a useless surface that also deteriorates the environment. At the moment the efforts for cultivation of ash dumping areas are present in some old mining districts of Slovenia which produce coal mainly for the needs of the power plants located in the same region. To achieve their adequate sanition and utilisation the electrofilter ash dumping areas were experimentally cultivated and used as pastures and hay production places for sheep. Such a method enables the ecological and productive use of the area, further proper compression and stabilisation of the ground performed by permanent movement of the herd, but above all the testing of successfulness of the fulfilled sanition through a permanent systematic detection of possible negative effects on sheep grazing on such pastures. Many substances ingested with food and water can manifest their harmful effects only after prolonged periods (Barberan et al. 1990). Accordingly, studies on influences of electrofilter ash used as a ground for pastures are long-term experiments, what can also represent the reason for very few data available on this problem in the relevant literature. Therefore the present study represents the first part of a long-term systematic investigation for possible negative effects on animals which will indicate the possibility of productive use of ecologically problematic ash dumping areas after cultivation. It is also supposed that the results of this initial experimental breeding will perform a starting point for specifically orientated experiments and analyses.

MATERIALS AND METHODS

The first phase of dumping area experimental sanitation was dedicated to the complete preparation of the ground. In this purpose the ash deposits

Correspondence to: U. Pestevšek

were spread out in the dumping areas in the depth from 2 to 4 metres and several month of watering and compression followed until proper stabilisation of the ground was assured. The second phase included conveying, spreading, compression and preparation of earth deposit (1/2 m of depth), planting of grass and corresponding one year maintenance of the grassland to reach the adequate preparation of pastures suitable for grazing of a smaller herd of sheep and preparation of hay for the needs of the winter nutrition. The pastures were later divided into grazing quarters, fenced, and equipped with a hangar for animal protection which included the hay-shed for the hay produced on the same location.

The experimental settling, grazing and the health and productive control of animals was planed as a survey of a minimum four years duration. For this purpose from a big herd of local sheep breed experimental and control group of 20 ewes (10 older ewes and 10 one year old ewes) each were formed. The experimental group was grazing on the newly cultivated pastures with the ground of electrofilter ash, and the control group on ordinary hilly pastures in the surrounding area. Detailed clinical and health control examinations, coprological testing and dehelminthization, establishing of body weight and haematological and biochemical status were performed by all animals prior settling to their location. At the same time the control of composition and nutritional value of grass from both locations was also done.
During the experiment health condition, body weight changes, haematological and biochemical status and reproductive performance of animals were permanently controlled. The offsprings of the ewes used in the study were included in the experiment each year. At the end of the first year two animals from each group (1 old ewe and 1 one year old ewe) were sacrificed and at the end of the second experimental year three animals from each group (one old ewe, one two years old ewe and one lamb) were sacrificed. Gross pathomorphological examinations were done by slaughtering of yearly sacrificed animals and at the same time different organs and tissues were taken for later hystological and other examinations. Toxicological and radiological studies of these tissues were performed using AOAC methods (AOAC 1995). Appropriate analyses of grass and hay produced on both areas were also made several times yearly using AOAC methods (AOAC 1995). After the first two experimental years the data were compared, statistically evaluated and the results summarised.

RESULTS AND DISCUSSION

The detailed quality examinations (Table1) showed that the nutritive values of grass, controlled eight times (four times yearly), were not significantly

different, but slightly better on experimental location. The quality of hay, controlled twice (once yearly), was regarding digestible proteins (55,8 g/kg : 44,6 g/kg) and starch units (321,5/kg : 294,0/kg) better on experimental area. These differences were statistically significant and by our opinion connected with substantial fertilisation of experimental meadows during preparation and cultivation.
The results of Ca, P, Mg, Ka, Na, Zn, Mn, Fe, Cu, Pb and Cd estimation in samples of grass and hay from both locations (Table 2) were within prescribed requirements (NRC - 1985). Resembling and statistically not significantly different values were stated also for U-238, Ra-226, Pb-210, Ra-228, Th-228, K-40, Be-7, Cs-137 and Cs-134 in grass and hay from both locations (Table 3). The mean values and all the results of considered single analysis were also lower from those given by corresponding legislation (Uradni list 1996).

However, the results of the up to the present analyses indicate that in the first two years after cultivation the electrofilter ash ground covered with soil had no influence on quantities and appearance of estimated minerals and radionuclides in the grass and hay.

Permanent veterinary control of both herds and the results of eight systematic health controls (4 each year), confirmed by haematological and

Table 1. Nutritional values of grass and hay from experimental and control location

Analysis	Grass experiment n=8	Grass control n=8	Hay experiment n=2	Hay control n=2
Dry matter % Variation	22,15 13,10 - 32,30	21,26 20,50 - 22,30	89,63 89,62 - 89.65	90,95 89,18 - 92,72
Proteins % Variation	3,86 3,22 - 5,00	3,40 2,73 - 4,64	9,74 8,05 - 11,43	8,41 7,18 - 9,63
Fibre % Variation	6,81 3,00 - 13,00	5,81 4,80 - 6,38	29,46 29,05 - 29,86	31,32 31,10 - 31,54
Fat % Variation	0,91 0,56 - 1,38	0,87 0,82 - 0,92	2,51 2,00 - 3,01	2,20 2,09 - 2,30
Ash % Variation	2,03 1,19 - 2,86	2,11 1,56 - 3,39	6,77 5,87 - 7,66	5,90 5,66 - 6,14
NFE % Variation	8,54 5,13 - 10,74	9,05 7,68 - 10,28	41,17 40,29 - 42,05	43,13 42,46 - 43,80
Dig. proteins g/kg Variation	26,74 24,10 - 28,00	24,68 20,0 - 3,41	55,80 [a] 41,00 - 70,60	44,60 [a] 35,00 - 54,20
Starch units / kg Variation	129,14 94,5 - 147,0	131,70 122,0 - 140,7	321,55 [b] 277,0 - 366,1	294,25 [b] 258,0 - 330,5

[a, b] The results signed with [a] differ by P<0,05, these signed with [b] differ by P<0,005

Table 2. Minerals in grass and hay from experimental and control location

Mineral	Grass experiment n=8	Grass control n=8	Hay experiment n=2	Hay control n=2
Ca - in g/kg Variation	1,66 1,11 - 2,25	1,42 1,05 - 2,10	4,14 4,07 - 4,22	3,31 2,60 - 4,03
P - in g/kg Variation	0,79 0,39 - 1,05	0,73 0,52 - 0,84	2,17 2,16 - 2,19	2,23 1,67 - 2,78
Mg - in g/kg Variation	1,23 0,67 - 2,22	1,17 0,44 - 1,68	2,01 1,17 - 2,85	1,19 0,85 - 1,53
K - in g/kg Variation	2,58 1,63 - 3,12	2,80 2,03 - 3,39	8,87 8,62 - 9,13	14,63 5,53 - 23,73
Na - in g/kg Variation	0,17 0,09 - 0,29	0,15 0,09 - 0,27	0,68 0,38 - 0,98	0,41 0,04 - 0,78
Zn - in mg/kg Variation	8,64 2,84 - 25,16	6,32 5,35 - 7 31	18,84 17,67 - 20,00	13,33 12,53 - 14,33
Mn - in mg/kg Variation	9,12 6,10 - 12,70	14,54 4,50 - 26,50	55,35 43,00 - 67,70	37,50 33,70 - 41,30
Fe - in mg/kg Variation	91,82 44,85 - 205,5	129,03 33,94 - 296,9	253,17 231,0 - 275,3	319,00 223,7 - 414,3
Cu - in mg/kg Variation	1,48 0,74 - 2,00	1,78 1,45 - 2,18	4,00 2,67 - 5,33	4,83 4,33 - 5,33
Pb - in mg/kg Variation	0,47 0,34 - 0,60	0,45 0,29 - 0,65	1,12 0,87- 1,37	0,96 0,64 - 1,27
Cd - in mg/kg Variation	0,06 0,03- 0,08	0.04 0,01 - 0,06	0 0	0,05 0,02 - 0,08

Table 3. γ activity of grass and hay from both locations (Bq/kg)

Element	Grass experiment n=8	Grass control n=8	Hay experiment n=2	Hay control n=2
U - 238 Variation	2,1 0,8 - 4,3	1,9 0,8 - 3,9	1,2 1,0 - 1.3	1,4 1,3 - 1,5
Ra - 226 Variation	3,7 2,3 - 5,2	3,1 1,5 - 6,4	1,8 1,8 - 1,9	1,4 1,1 - 1,6
Pb - 210 Variation	22,6 8,5 - 40,0	33,1 15,5 - 55,0	9,0 8,0 - 10,0	5,5 5,0 - 6,0
Ra - 228 Variation	0,9 0,8 - 1,0	2,0 0,7 - 3,6	0,9 0,7 - 1,0	0,8 0,6 - 1,0
Th - 228 Variation	0,7 0,5 - 0,8	1,5 0,5 - 3,5	0,5 0,4 - 0,6	0,7 0,5 - 0,9
K - 40 Variation	802,0 692,0 - 870,0	701,0 520,0 - 902,0	694,0 663,0 - 725,0	608,0 593,0 - 680,0
Be - 7 Variation	240,5 165,0 - 316,0	192,0 154,0 - 230,0	28,0 *	23,0 *
Cs -137 Variation	0,8 0,3 - 1,1	0,9 0,6 - 1,5	0,3 0,2 - 0,5	0,3 0,2 - 0,4
Cs -134 Variation	**	0,3 0,2 - 0,4	**	**

* testing of one single sample (n = 1)
** under detection limit

biochemical analyses of blood sera, also showed good health status of all animals from both groups during the two years experimental period. Control of weight, performed 8 times in two years, showed better average weight gain of sheep in the experimental group (Table 4). The difference between both groups was significant (F=7,60; P<0,01) but can be explained by demanding conditions and lower nutritional value of hilly pastures. Greater standard deviations stated at the beginning of the experiment are due to the structure of the groups that were composed from older ewes (n=10) and one year old ewes (n=10).

All the ewes mated at the end of the first experimental year with the same ram. The lambing in both groups lasted from February to March.

Table 4. Changes of body weight by ewes (kg)

	Control 1 n=20	Control 3 n=20	Control 5 n=18	Control 8 n=16
Experimental group	45,60	54,60	70,84	77,88
SD±	22,30	13,38	10,70	8,62
Variation	18,5 -73,0	36,0 -75,5	54,5 -90,0	60,0 -88,5
Control group	43,58	50,75	68,64	70,19
SD±	22,34	13,65	10,65	5,60
Variation	17,0 - 80,0	30,5 -77,5	54,0 -87,0	61,0 -81,5

Table 5. Average body weight of lambs at birth and in the first 75 days (kg)

	At birth	At age of 30 days	At age of 45 days	At age of 75 days
Experimental group (n=25)	4,02	10,32	16,64	22,27
SD±	0,96	3,11	3,26	4,31
Variation	2,6 - 6,0	5,2 - 19,6	8,5 - 24,5	17,0 -32,0
Control group (n=23)	4,03	10,00	16,76	23,70
SD±	0,63	2,68	4,10	3,54
Variation	2,8 - 5,2	4,0 - 14,0	7,0 - 23,0	20,5 -30,0

Ewes from experimental group (n=18) gave birth to 26 lambs (16 females and 10 males) and ewes from control group (n =18) to 25 lambs (16 females and 9 males). In the experimental group 1 stillborn lamb and in the control group 2 stillborn lambs were stated. There was no significant difference between lambs of both groups regarding birth body weight and body weight gaining in the first 75 days of their life (see Table 5).

In the two experimental years at the necropsy of sheep no gross or microscopic pathologic differences between the experimental and control group, which could be related to the influence of electrofilter ash, except the difference in the size and weight of adrenal and thyroid glands, were found. When the weights of both glands were recalculated and estimated as percentage of body weight or as a ratio between glands and body weight, those differences were minimal and not significant. This is in agreement with the results of other authors (Coulter et al. 1989; Juntes et al. 1996; Nicolle et al. 1990). In our opinion the difference in the weight of the glands can be attributed to the lower body weight of sheep in the control group.

The amounts of heavy metals and radionuclides K-40 and Cs-137 stated in tissues (muscle, liver, kidney, lungs and bones) of experimental and control animals were lower from those given by corresponding legislation (Uradni list 1987). The results were also in good agreement with those found for cattle and pig tissues in Slovenia (Doganoc 1996). No significant difference was observed also when comparing the results stated in samples of experimental and control group. From this point of view mentioned tissues were considered suitable for human nutrition.

Table 6. Heavy metals in samples of animal tissues (mg/kg)

Sample (n=5)	Pb	Cd	Cu	As
MUSCLE				
Experimental group	<0,050	<0,003	0,816	<0,050
Control group	0, 070	<0,003	0,987	<0,050
LIVER				
Experimental group	0,084	0,069	7,630	<0,050
Control group	0,092	0,090	10,826	<0,050
KIDNEY				
Experimental group	0,082	0,214	6,640	<0,050
Control group	0,088	0,366	5,284	<0,050

It can be concluded that the nutritive values of grass were not significantly different, but slightly better on experimental location. The quality of hay was regarding digestible proteins and starch units better on experimental area. These differences were statistically significant and connected with substantial fertilisation of experimental meadows during preparation and cultivation. Comparative weight control of animals showed lower weight gain in experimental group what was most probably influenced by lower nutritional value of food and demanding conditions of hilly pastures.

However the average body weight of lambs at birth and their latter body weight gains in the first 75 days of life did not differ between groups.

Table 7. Radionuclides in samples of animal tissues (Bq/kg)

Sample (n=5)	K - 40	Cs - 137
BONES		
Experimental group	7,30 ± 1,00	< 0,1
Control group	9,60 ± 0,75	< 0,3
MUSCLE		
Experimental group	126,0 ± 8,10	< 0,3
Control group	138,0 ± 9,40	< 0,3
LUNGS		
Experimental group	40,0 ± 3,10	< 0,3
Control group	44,0 ± 4,00	< 0,3
KIDNEY		
Experimental group	43,0 ± 3,20	< 0,3
Control group	39,0 ± 3,10	< 0,3

Regarding the results of regular health controls, biochemical analysis of blood as well as hystological, pathological, toxicological and radiological analysis following control slaughtering, no significant difference was observed between both herds up to now. The differences in the size and weight of adrenal and thyroid glands which were considered to be individual and connected to the body weight differences are at present not attributed to the effects of electrofilter ash but these findings have to be confirmed during further experimental period.

Acknowledgments. The project was professionally and financially supported by Coal Mine Velenje and enabled by financial aid of Ministry of Science of Republic Slovenia to which we owe our thanks. We especially thank the staff of Jozef Stefan Institute - Department of environmental sciences - Laboratory for radiochemistry for proper analyses.

REFERENCES

AOAC (1995) Official methods of analysis of the AOAC. 16th edition - AOAC, Washington, D.C.

Barberan M, Valderrabano J, Bascuas JA (1990) Histopathological changes in ewe lambs exposed to prolonged diet on lucerne. Ann Rech Vet 21: 161-166.

Coulter CL, Young IR, Browne CA, McMillen IC (1989) Different roles for the pituitary and adrenal cortex in the control of enkephalin peptide localization and cortico-medullary interaction in the sheep adrenal during development. Acta Endocrinol 120: 301-307.

Doganoc DZ (1996) Lead and cadmium concentration in meat, liver and kidney of Slovenian cattle and pigs from 1989 to 1993. Food Add Contam 13: 237-241.

Juntes P, Pestevšek U, Pogačnik M (1996) Morphometric analysis of adrenal gland cortex of sheep grazing on pastures with the ground of electrofilter ash. In: Life science 1996, Gozd Martuljek, 199-200.

Nicolle A, Bosc MJ (1990) A quantitative histological study of adrenal development during late gestation and the perinatal period in intact and hypophysectomized fetal sheep. Reprod Nutr Dev 30: 653-662.

N R C (1985) Nutrient requirements of sheep. National Research Council , National Academy Press, Washington D.C.

Uradni list (1987) Pravilnik o spremembah in dopolnitvah pravilnika o količinah pesticidov in drugih strupenih snovi, hormonov, antibiotikov in mikotoksinov, ki smejo biti v živilih. Uradni list SFRJ, Beograd, Jugoslavija 79/1987: 1842-1846.

Uradni list (1996) Pravilnik o zdravstveni ustreznosti krme. Uradni list RS, Ljubljana, Slovenija 20/1996: 1634-1644.