UNITED NATIONS

E

Economic and Social Council

Distr.
RESTRICTED

ENERGY/WP.2/GE.1/R.23/Add.2
4 July 1995

ENGLISH
Original: RUSSIAN

ECONOMIC COMMISSION FOR EUROPE

COMMITTEE ON ENERGY

WORKING PARTY ON ELECTRIC POWER

Meeting of Experts on Electric Power
Generation and the Environment
Fifth session, 25-26 September 1995
6 (i) of the provisional agenda

METHODS OF IMPROVING THE ENVIRONMENT IN AREAS AROUND EXISTING AND ABANDONED SLAG HEAPS FROM ELECTRIC POWER PLANTS

Transmitted by the Government of the Russian Federation*

1. Large areas of land given over to ash tips are a typical feature of power stations burning solid fuel. There were 20,000 ha of such tips in the Russian Federation at the end of 1993.

2. As gas replaces solid fuel or ash tips are filled, the rehabilitation or maintenance of the tips becomes a problem in that it is not feasible to recycle all the ash in abandoned tips at thermal power stations.

3. Ash tips have to be rehabilitated or maintained because ash blowing from the surface adversely affects the environment. How serious the effect is depends on the chemical composition and fineness of the ash.

---

* In accordance with the decision of the Meeting of Experts at its fourth session, held in September 1994 (ENERGY/WP.2/GE.1/8, para. 39).

4. Chemically, 98% of ash consists of oxides - SiO_2, Al_2O_3, Fe_2O_3, CaO. MgO, K_2O, and Na_2O - and while the iron, potassium and sodium oxide content varies within an insignificant range, silicon, magnesium, aluminium and calcium oxide content can differ by a factor of two or more. The quantities of trace elements in coal ash also vary significantly. For example, the chromium content in ash from Kansk-Achinsk coal is 123 g/t, but 5 g/t in Kuznetsk coal; there is 1,429 g/t of manganese in Kansk-Achinsk coal ash, 98 g/t in Moscow coal ash.

5. Ash contains small quantities of radionuclides which evidently pose no risk to humans or the environment; it must be pointed out, however, that this is a matter that has not been sufficiently studied yet.

6. The harmful effects of ash depend not only on the toxicity of the chemical compounds within it but also on the sites of these compounds within the ash particles. Analysis of the distribution of the main chemical elements within the crystalline matrix of ash and the vitreous envelope surrounding it shows that all the calcium, magnesium, arsenic, molybdenum, cadmium and zinc is found in the envelope; the chromium, copper and lead are distributed evenly through the envelope and matrix, and the silicon and nickel tend to be localized in the crystalline matrix.

7. It has been found, in experiments set up to determine the contribution of individual components of ash to the toxic effect, that copper ions accumulating in animal livers disrupt liver function, while the presence of silicone dioxide in ash is not accompanied by the fibrogenicity characteristic of crystalline SiO_2.

8. In health terms, the fineness of ash particles blown off the surface of ash tips is also important, for particles larger than 12 µm in size are almost all trapped in the upper respiratory passages and eliminated fairly thoroughly; particles 1 µm and smaller penetrate into the lower respiratory tract and can persist there for long periods. Fine ash particles are easily blown off ash tips, can be carried large distances, and penetrate the soil deeply. They also contain higher concentrations of arsenic, cadmium and copper.

9. Investigations by Russian scientists into the environmental effects of ash with a high calcium oxide content have shown that in areas of heavy ash deposition the pH of the soil changed over a long period from mildly acidic to mildly alkaline and the ash facilitated the accumulation in the soil of higher concentrations of calcium, iron and magnesium while organic carbon content dropped; in other words, there was a significant change in soil quality which could not [but] affect plant life.

10. Trees in such soil absorb more magnesium, iron and copper and experience manganese and barium deficiencies. The result is metabolic disruptions. In young pines these express themselves as giant trunks and dwarf shoots and needles, culminating in the death of the shoots. Birch and aspen show signs of premature ageing, retarded growth and thinning of the crowns in mature trees.

11. Changes in the chemical composition of grasses are broadly similar to those in trees; manganese and barium content declines, magnesium and copper content rises. Unlike trees, however, grasses absorb calcium more actively and calcifugous plants therefore suffer significantly more, while calcium-loving plants tend to do rather better, with well-developed root systems and increased biomass.

12. Addition of high-calcium ash in appropriate doses is observed to improve the growth and increase the yields of plants such as potatoes and wheat by comparison with controls. At high doses (over 75 t/ha for wheat) the adverse effects of the ash begin to show: the roots form a superficial system and the plants themselves display dwarfism.

13. At higher than established concentrations in the soil, acidic ash has a stronger effect on plants than alkalinic: the plants' manganese, vanadium and cobalt content increases four- to tenfold, potassium, sodium, nitrogen and calcium content declines and both the yield and the nutritive value of fodder grasses fall.

14. In some experiments, plants set in a mixture of low-calcium ash and soil absorbed increased quantities of arsenic, aluminium, manganese and molybdenum; the concentrations attained were potentially dangerous both for the plants and for grazing animals.

15. Addition of acidic ash to soil lowers its pH value, and this adversely affects such trees as birch, which grows well at pH of 5.8-7.5, and calcium-loving plants. The pH value is an important factor in the absorption by plants of heavy metals. At low (2.5-3.0) and high (9.0-10.5) pH, heavy metals accumulate significantly more intensively than in neutral soil.

16. The adverse effects of ash blown off ash tips are visible at given concentrations both in the air and in the soil, but this depends on a range of conditions, among them the area and height above ground of the abandoned tip; the shape of the tips and direction of the prevailing winds; wind speed and the number of windy days during the hot, dry period of the year; and the fineness and dryness of the ashy material. The quantity of blown ash depends on the area of the tip, and the extent of the dust plume, on the height.

17. When a dust cloud forms from ash particles blown off a tip, several characteristic zones emerge: in the first, the particles are carried into the air by the wind and have no chance to settle, and dust concentration rises parabolically; in the second, dust concentration rises in a near-linear manner since particles picked up by the wind in the first zone begin to settle; in the third, beyond the ash tip, dust concentrations in the air diminish as ash particles settle.

18. Field trials and wind-tunnel tests on ash have shown that ash blow-off depends on wind speed and ash particle size; particles larger than 1 mm are carried away by winds of over 10 m/s; particles between 1 and 0.4 mm are carried away by winds of over 7 m/s, and particles of less than 0.4 mm in size are carried away by winds of over 2 m/s.

19. Blow-off occurs when the moisture content of the ash is not higher than 3%.

20. Investigations and calculations of the dispersion of airborne ash from ash tips indicate that when winds are strong, greater then permissible ash concentrations may be observed up to 4 km from the periphery of a tip.

21. Abandoned ash tips are rehabilitated (maintained) in order to prevent them from adversely affecting the environment.

22. Biologically speaking, ashy material is a sterile substrate containing no organic substances or traces of nitrogen. The quantities of free phosphorus and potassium are also too small to support plant life; there are virtually none of the micro-organisms that serve to provide stable, fertile soil and normal humic and mineral nutrients for plants.

23. Because of the unfavourable physical and chemical properties of ash, tips are slow to grow over, especially where not enough moisture is deposited and winds are strong. The first plants appear two or three years after a tip is abandoned; as a rule, these are examples of local flora. They occur in hollows, and bind no more than 20-30% of the surface of the tip.

24. The main approaches to tip rehabilitation, depending on the intended use, are:

(a) Agricultural - creation of pasture, meadowland and grazing on the waste land;

(b) Forestry - plantation of trees to bind the soil and for commercial exploitation;

(c) Health and safety - binding tips it would not be economical to rehabilitate for agriculture;

(d) Construction - getting the waste land into a suitable condition for industrial and civic construction.

25. The latter three approaches to tip rehabilitation are most commonly seen in the Russian Federation.

26. The means used to fix the surface of abandoned tips can be divided into three main categories:

- mixing complete mineral fertilizer into the ash and sowing a mixture of grasses;

- covering the surface of the tip with organic material and sowing a selection of grasses;

- planting saplings and bushes in holes that have been filled with soil.

27. Attempts to grow plants in neat ash to which high doses of mineral fertilizer have been added have shown that the plants will grow only if they are systematically watered, and yields are low; there is always a danger that the seeds will be carried away by the wind or washed away by rain.

28. The most effective means of binding the surface of an ash tip is to cover it with a 15-20 cm thick layer of earth and sow it with pulses and cereals. On some tips where there was not enough earth to cover the entire surface, the earth has been laid in strips and sown, again in strips, with a selected mixture of grasses.

29. Where tips have been planted with trees and bushes, the best results have been obtained with three- to four-year-old saplings planted at 1 x 1.5 m intervals in holes filled with soil. The saplings have to be tended for several years.

30. Agricultural rehabilitation of abandoned ash tips is a subject that has not yet been adequately studied; the economics of such rehabilitation apart, it must be borne in mind that the roots of the plants, penetrating through the soil into the ash, accumulate a variety of trace elements which may rise to above permissible concentrations in the roots and leaves for grazing by animals. The uptake of trace elements depends not only on the chemical composition of the ash but on the type of plant - different varieties absorb the same trace element to different degrees. As mentioned above, the pH index also affects plant uptake of heavy metals: absorption rises significantly at both very low and very high pH values.

31. Accordingly, agricultural rehabilitation requires a layer of earth covering the ash tip that is deeper than the roots of the plants to be grown on it. This will prevent the roots from penetrating into the ash and, hence, prevent the plants from accumulating high doses of trace elements. Such a recommendation is hard to follow, however, since the active length of some agricultural plants is two metres and over; repeated grazing of an insubstantial layer of earth may bring up a layer of ash.

32. Some examples of ash tip rehabilitation (maintenance) at thermal power stations in the Russian Federation are offered below.

Southern Urals

33. An abandoned tip contains ash from Chelyabinsk brown coal. The ash contains virtually no nitrogen, and small quantities of phosphorus and potassium. It was rehabilitated in 1964-1966 by being covered with earth to a depth of 20-30 cm and sown with perennial grasses (sainfoin, bromegrass, couch-grass and lucerne).

34. Investigation of this tip over the 10 years following rehabilitation revealed that the entire surface grew over with a variety of wild grasses and the planted pulses almost completely disappeared; by the time 20 years had passed, even the smooth brome was gone. Grassing on a small area of tip that had not been covered with earth was delayed by 10-12 years. The process later picked up and by the time 20 years had passed a community of meadow grasses and grains had developed there too.

Verkhny Tagil

35. The abandoned ash tip is full of brown coal ash containing traces of nitrogen, small quantities of potassium and large quantities of active phosphates. There not being enough earth to cover it over completely, it was earthed in strips which were planted with perennial grasses. Trees were planted on one small area. Earthing in strips promoted faster binding of the surface, and the tree planting, together with the presence of a nearby area of woodland, has enabled it to become set with willow, birch and pine.

Rublevsky pit

36. Ash from the tips of Moscow's thermal power stations, where it was planned to use abandoned tips for industrial and housing construction, was dumped for a number of years in an 80 ha gravel pit. When dumping ended, the surface of the ash was covered with earth to a depth of 80 cm and sown with cereal grasses. The tip is now heavily grassed over and 80% bound, and the root systems of the grasses are well developed and extend to a depth of one metre. Small numbers of willows and other trees are growing around the edge of the tip.

Conclusions

37. Abandoned, unrehabilitated ash tips can be sources of atmospheric and soil pollution.

38. Research and experience show that the best ways of preventing dust blow-off from tips (preventive rehabilitation) are to:

(a) Cover the surface with a 10-25 cm thick layer of fertile or potentially fertile earth. To hasten growth, perennial grasses are sown and mineral or organic fertilizer is added;

(b) Plant saplings and bushes in holes filled with earth.

39. Ash tips can be used for industrial and civic construction.

40. Agricultural rehabilitation of ash tips requires special research into the accumulation of trace elements by plants and the influence of such take-up on animals and humans; it also requires heavy capital investment.
