

MSWI RESIDUES IN THE NETHERLANDS PUTTING POLICY INTO PRACTICE

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Abstract

The Dutch policy with regard to the residues of Municipal Solid Waste Incineration (MSWI) aims towards maximization of useful application and minimization of required volume for disposal of these residues. This policy has been put into practice successfully for MSWI bottom ash. During recent years, virtually all bottom ash has found a useful application in road construction and embankments. In the case of MSWI fly ash, the policy led to the use of this material as a filler in asphalt for road construction. The demand for asphalt fillers containing MSWI fly ash, however, is limited. As a result only 20 - 30 % of the MSWI fly ash produced has been usefully applied as an asphalt filler. For the residues from flue gas scrubbing, no feasible useful application has been found to date. As a result, the entire production has been disposed of in landfills. Long term policy, however, also aims towards the development of uses for flue gas scrubbing salts.

1. INTRODUCTION

The principle goal of MSW incineration is reducing the amount of space required for disposal of wastes in landfills. Incineration of MSW is preferred in the Netherlands. This preference is also an integral part of the regulations currently applicable in this respect. Incineration of MSW results in residues, typically occupying about 10% of the original volume (and 25% of the weight) of the incinerated waste. Useful application of these residues further increases the waste reduction, and therefore reduced the amount of space required for landfills.

The Dutch policy not only takes into account the limited space available for land-fill, it also aims towards preserving natural resources. The total annual consumption of building materials in this country amounts 140 million tons. This consumption - primarily sand, gravel, clay and marl - results in a considerable loss of natural resources. These two aims lead to an increase of the useful application of residues, including those from MSW incineration.

Like virtually all residues that can be used as secondary building materials, MSWI residues are contaminated, posing a potential risk of soil pollution. We are therefore faced with a paradox: use of residues is beneficial to the environment in the sense that it preserves natural resources, while in itself this use poses the potential environmental threat of leaching contaminants into the soil. To resolve this dilemma, regulatory measures have been stipulated for the use of residues, including MSWI residues.

2. GENERAL POLICY FOR MSWI RESIDUES

In the period from 1990 through 1997, environmental legislation has changed drastically in the Netherlands. This has also affected useful application and disposal of MSWI residues. Briefly, the high standard of re-use of MSWI residues must be consolidated despite increasingly stringent environmental legislation. To this end, the government and the other parties involved are attempting

to work together as much as possible. This cooperation resulted in the creation of a 'Policy Paper MSWI residues' (March 1995). In this document (in Dutch: 'Implementation-plan AVI-reststoffen' [1]) a common course is set for the future. In order to coordinate the 36 proposals laid down in this Policy Paper, the 'Service Center MSWI residues' (acronym in Dutch: ACR) was established in mid-1995. The ACR is a temporary organization located at the office of the Waste Processing Association. The latter will be responsible for acting on most of the proposals. The objective of the ACR is to finalize all proposals as agreed by 1998.

3. POLICY FOR MSWI BOTTOM ASH

The 'Policy Paper MSWI residues' summarizes the policy for MSWI bottom ash as follows:

1. Continuation of the current re-use figure (almost 100%) despite increased production.
2. Application of MSWI bottom ash preferably as replacement for sand in embankments in projects of at least 10,000 tons. Incentive for application in projects of 100,000 tons or more.
3. Bottom ash that does not meet common regulatory environmental quality standards (N2-status of the Dutch Building Materials Decree) is only to be used in government-controlled projects.
4. Improvement of the environmental quality in order to achieve N2-status, preferably by 1997.

4. PRACTICE OF MSWI BOTTOM ASH

4.1 Continuation of the current re-use figure (almost 100%)

In the Netherlands, raw MSWI bottom ash is upgraded prior to useful application. This upgrading has been described in detail elsewhere [2]. In short, upgrading consists of magnetically removing scrap material, and crushing and sieving to remove all components with a diameter larger than 40 mm. The non-combusted material present in the fraction > 40 mm is normally recycled back to the incinerator.

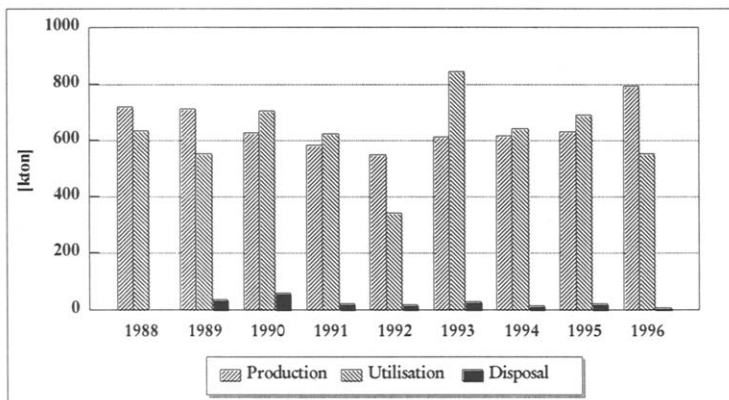


Figure 1 Production and use of MSWI bottom ash in The Netherlands

By means of this upgrading, the resulting MSWI bottom ash is transformed into a secondary building material. All MSWI bottom ash that has been produced over the past ten years has therefore found

useful application, primarily in embankments and road-base layers. The yearly production and use of MSWI bottom ash is depicted in Figure 1.

Quality control and quality assurance can be regarded as one of the reasons for the present success of MSWI bottom ash in The Netherlands. In recent years, certification has become an important activity, nowadays covering the majority of MSWI bottom ash (Figure 2).

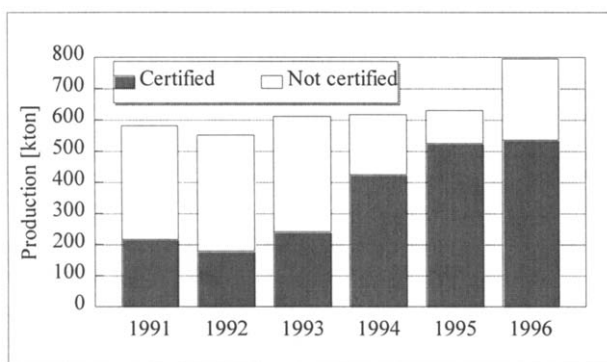


Figure 2 Certification rate of MSWI bottom ash

Untreated MSWI bottom ash contains about 10% retrievable ferrous metals. Annually some 65,000 to 75,000 tons of recovered steel scrap is recycled in the steel industry. Because the retrievable ferrous metals give a positive revenue, some of the processing costs are compensated. Most Dutch MSWIs (will) recover non-ferrous metals by applying Eddy-Current techniques as well. In 1996 some 1,700 tons of non-ferrous metals were recovered. Within a few years, this figure is expected to rise to about 3,500 to 5,000 tons (based on an expected annual production of more than 1,000,000 tons of MSWI bottom ash), depending on the methods for non-ferrous retrieval to be implemented. It should be noted that non-ferrous separation produces a better quality bottom ash and that the revenues of non-ferrous are such that it is considered a worthwhile investment.

It can be concluded that every effort is being made to upgrade MSWI bottom ash to a generally-accepted secondary building material. Over the past then years this effort has been rewarded by the market, in the sense that virtually all upgraded bottom ash has found useful application.

4.2 Preference for use in large projects

Until the early eighties, MSWI bottom ash was used in predominantly small projects. The majority of these projects consisted of road-base construction and simple use as a paving material for (farm) yards. The latter projects had an average quantity of only 30 tons. This type of project has always been regarded as unsuitable by the government. The proposed Building Materials Decree (to be fully implemented in 1998) therefore prohibits the use of MSWI bottom ash in projects involving less than 10,000 tons. In the mean time, preferential use of MSWI bottom ash in large projects has been stimulated by all parties involved. This policy presents logistical problems, however. MSWI bottom ash is continuously produced while large projects that are suitable for MSWI bottom ash occur only incidentally. Most MSWIs are able to stockpile the amount of bottom ash that is produced in one year, which appears to be sufficient for a majority of the projects. Recently an embankment was constructed using almost 1,000,000 tons of bottom ash. The size of this project required an intermediate stockpile near the project itself.

In order to verify whether the agreed preference for large projects is implemented in practice, the ACR monitors the projects in which MSWI bottom ash is used. Figure 3 depicts the market share of

large (> 100,000 tons), intermediate (between 10,000 and 100,000 tons) and small scale projects (< 10,000 ton). In recent years, more than 2/3 of the bottom ash has been used in large-scale projects. In addition, projects involving 10,000 ton or less now comprise less than 5% of the market (Figure 3). One of the targets of the policy for MSWI bottom ash has therefore been implemented in practice: a majority of the material is used in large-scale projects. Moreover, in the near future the use of MSWI bottom ash in projects smaller than 10,000 tons will be prohibited by the Building Materials Decree.

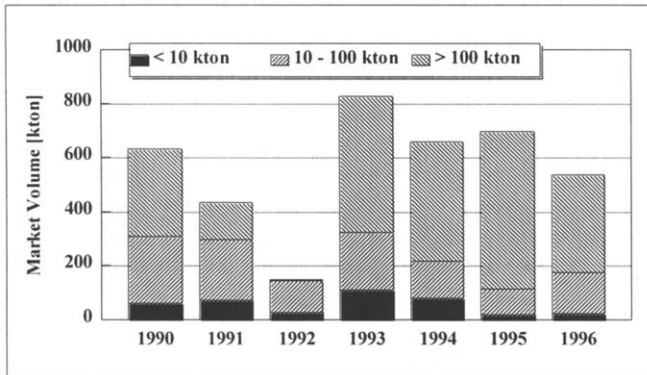


Figure 3 Size of projects in which MSWI bottom ash is used.

4.3 Preference for use in projects by order of the government

The Dutch governmental structure consists of three layers: national authorities (ministry of Public Works), provinces and municipalities, which all order projects for road construction and embankments. With respect to large projects, the ministry of Public Works is the most likely candidate for ordering these projects to be constructed with MSWI bottom ash. Although this ministry is a strong advocate of use of secondary building materials in large projects, it holds the view that the provinces and municipalities also should take their responsibility in using MSWI bottom ash in their projects.

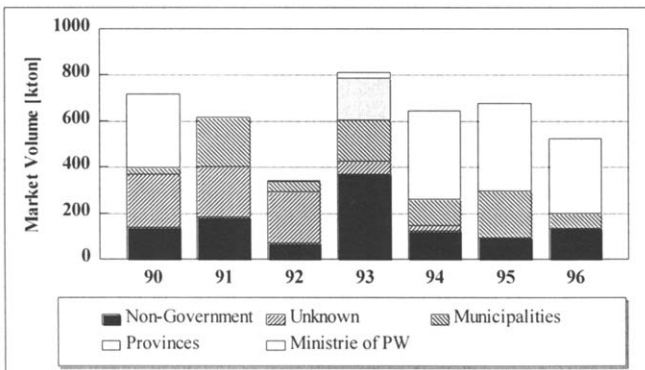


Figure 4 Ordering of MSWI bottom ash.

The ACR monitors the actual market for MSWI bottom ash itemized per category of Government. In Figure 4 the results are shown, indicating that over 75% of the bottom ash is used by municipalities

and the ministry of Public Works. This result approaches the objective of 100% that has been determined in the policy for MSWI bottom ash. Yet non-government users are still needed to ensure that a considerable fraction of the production need not be dumped in landfills. It should also be noted that off-take by the ministry of Public Works can vary widely from one year to the next. In short, additional effort is required from all parties involved at this point in time if the desired level of 100% sale to government-controlled users is to be reached.

4.4 Improvement of the environmental quality

The current successful use of MSWI bottom ash will be continued in the future. The strict environmental demands as presented in the 'Building Materials Decree' require the development of new techniques in order to improve the environmental quality of MSWI bottom ash. The current environmental quality of bottom ash does not meet the requirements as formulated in the 'Building Materials Decree' with respect to the leaching behavior of Copper, Molybdenum, Antimony and Bromide. Although practical uses will remain possible within the boundaries of future regulatory demands, the required precautions (such as the use of polyethylene and sand-bentonite liners) will probably weaken the market competitiveness of MSWI bottom ash. By improving the environmental quality of MSWI bottom ash, its market-share can be secured. The benefits of improved environmental quality are recognized by the 'Policy Paper MSWI residues', which has adopted this as one of the objectives for MSWI bottom ash.

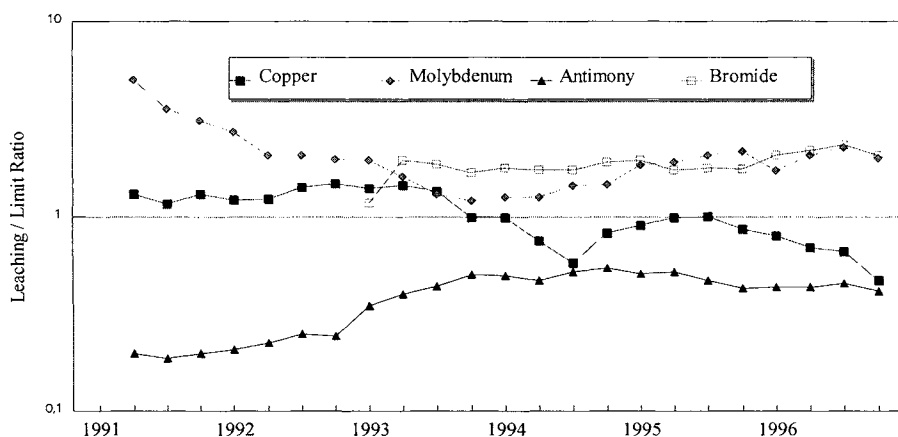


Figure 5 Leaching of MSWI bottom ash related to the demands for granular materials (N2) of the 'Building Materials Decree'

Briefly, the leaching of Antimony, Copper, Molybdenum and Bromide must be reduced in order to meet the general quality standards as laid down in the Building Materials Decree (Figure 5). During the period from 1992 until 1996, laboratory research and studies have been performed in search of applicable techniques for improving the leaching behavior. At the end of 1996 it was decided that both scrubbing MSWI bottom ash and accelerated aging of the materials as well as the use of additives were techniques worth testing on a larger scale. In 1997 accelerated aging of MSWI bottom ash will be tested on a pilot-plant scale (batches of 50 tons). In addition, process-integrated scrubbing of MSWI bottom ash using the quench will be tested at two different MSWIs. Depending on the results, a decision concerning implementation of one - or both - of these techniques will be made

early in 1998. Based on this time schedule, the required quality improvement should be reached at the end of the year 1999.

Reduction of the leaching is regarded as a tool for maintaining the high level of use of MSWI bottom ash; it is not an objective in itself. In fact, the 'Policy Paper MSWI residues' aims towards 100% use of MSWI bottom ash, even if it does not meet the desired environmental quality. Should the techniques explained above fail to achieve the desired quality, or if they succeed only against high financial or environmental costs, it can as yet be decided that the techniques will not be implemented. In any case, the results of the large-scale experiments will probably lead to some debate about the question of whether the advantages of an improved quality justify the financial costs and environmental side-effects (e.g. discharge of waste water in case of scrubbing).

5. POLICY FOR MSWI FLY ASH

The 'Policy Paper MSWI residues' formulates the policy for MSWI fly ash as follows:

1. Continuation of the application as a filler in asphalt pavements.
2. Re-use of the remaining fly ash fraction by applying solidification techniques
3. In the case of disposal, quality improvement to a C3-class hazardous waste.

In addition to the 'Policy Paper MSWI residues', other regulatory factors affect the manner in which policy for MSWI fly ash is put into practice. Due to its leaching behavior, MSWI fly ash is categorized as a C2-class hazardous waste. Disposal of C2-class (*i.e.* untreated) MSWI fly ash in landfills will be prohibited as from 1998. Improvement of the environmental quality of fly ash is therefore required in order to increase its uses and to make it possible to continue to dispose of the remaining fraction in landfills.

6. PRACTICE OF MSWI FLY ASH

6.1 Continuation of the application as a filler in asphalt

After years of decline, the production of MSWI bottom ash rose once again in 1996. This increase was brought about by the raise of incineration capacity in The Netherlands. The gradual decrease of the amount of fly ash produced can be explained by the modernization program of the MSW incineration capacity over the past years. Not only the flue gas emissions were reduced as a result of this modernization, but the amount of fly ash per ton of waste was almost halved (1990: 3.0%, 1996 1.6%) as well. Since the early eighties, MSWI fly ash has been used as a filler in asphalt in the Netherlands. On average, 20 kton of fly ash is used this way every year. Due to the limited capacity of the market for asphalt - and thus for asphalt fillers - in the Netherlands, the re-use figure for fly ash cannot increase substantially unless other uses are developed. MSWI fly ash replaces part of the lime present in asphalt-filler. About 30% of the filler mixture consists of fly ash. The water repellent properties of bitumen ensure low leachability of contaminants. The resulting asphalt meets the environmental demands formulated in the 'Building Materials Decree'. This is a result of the fact that bitumen encapsulates the fly ash particles and only 2% of fly ash is present in the asphalt.

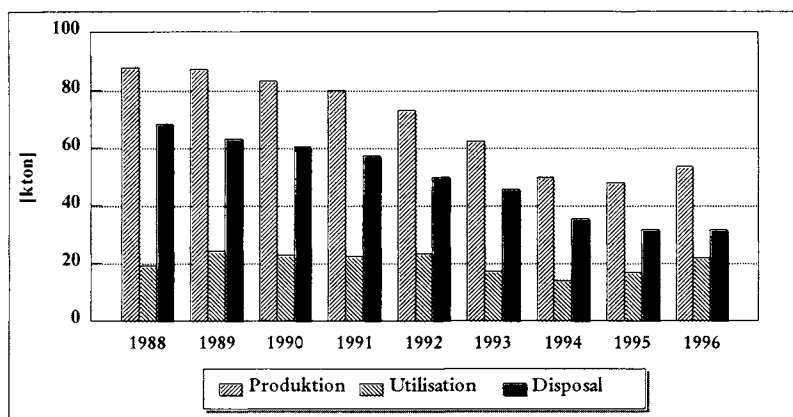


Figure 6 Production and use of MSWI fly ash in The Netherlands

6.2 Treatment of MSWI fly ash and subsequent use or disposal

As mentioned above, landfilling with MSWI fly ash will be prohibited as from January 1998 unless the leachability is reduced. In order to develop alternatives for landfilling, an extensive research program has been launched. The objective of this program is to explore options for reducing the leaching behavior of MSWI fly ash so as to produce a secondary building material or a C3-class waste material. In addition, the possibility of use of fly ash as an additive in concrete has been investigated.

Solidification

Solidification involves the fixation of heavy metals, usually by employing cement and additives, in order to reduce their leachability. This quality improvement would result in a shift in landfilling category: C3-status instead of C2. Under more favorable conditions, solidified waste materials could be used as building materials. In recent years numerous solidification techniques and formulae have been tested. Until now, however, none of these have produced the required class-C3 landfill quality. Application as a building material is also impossible. The problems are caused by insufficient fixation of the soluble salts, such as chlorides and bromides. It should be noted that the failure of solidification techniques in treating MSWI does not apply to other types of waste materials which may contain less soluble salts. Soluble salt can be removed easily by applying washing techniques. This option, however, introduces contaminated waste-water. Only a limited number of Dutch MSWIs are permitted to discharge waste water at all. Thus the combination of solidification and washing is a virtually unfeasible option for most of the MSWIs in The Netherlands.

Melting of MSWI fly ash

Melting is regarded as a suitable technique for transforming MSWI fly ash into building materials. And yet the high operating temperatures of these melting processes - at least 1300°C - require a great deal of energy and expense. It is therefore generally accepted that melting techniques are only cost-effective when the products can be used in a practical way. The quality of the melting products is considered, therefore, in conjunction with the standards for building materials rather than those for landfilling. Since 1993, the Waste Processing Association has commissioned several laboratory research projects and feasibility studies concerning melting of MSWI fly ash. However, it was ultimately concluded that larger scale experiments were essential before any definite conclusions could be made. On behalf of one of the members of the Waste Processing Association two pilot-scale

melting experiments have been performed using different melting techniques. The resulting granular products have been compared with the Dutch 'Building Materials Decree'. It appeared that the leaching of Antimony did not meet the standards for unrestricted useful application within the framework of the legislation mentioned. The members of the Waste Processing Association therefore believe that the over-all feasibility (quality of the product, energy consumption, resulting residues) do not justify continued development of this technique.

Use as an additive in concrete

In 1995 and 1996 the 'Service Center MSWI residues' commissioned two studies concerning the feasibility of use of fly ash as a pozzolanic additive in concrete. MSWI fly ash can be used in concrete in three ways:

- as filler to obtain high density concrete;
- as partial cement replacement;
- as a high value additive after further size reduction (micronized ash, wet grinding).

The application of MSWI fly ash in concrete is similar to its use as a filler in asphalt. The technical specifications for concrete, however, are more stringent. Based on the technical, environmental and economical properties, this option appeared technically feasible providing that the fly ash is scrubbed prior to pretreatment (milling). Again, the cause for this inevitable scrubbing step is the presence of soluble salts in MSWI fly ash. Without scrubbing before use of the ash, the leaching of the resulting concrete exceeds the limits for bromide as formulated in the 'Building Materials Decree'. Filler containing MSWI fly ash can not be used in re-enforced concrete due to the corrosive action of the chloride it contains. Removal of chlorides is required when use in reinforced concrete is considered. As stated above, scrubbing the fly ash introduces the problem of waste water. Taking into account that the balance of revenues and total costs are not much better than the current practice of disposing of untreated MSWI fly ash in landfills, the over-all feasibility of use in concrete is probably marginal.

Use in German salt or coal mines

In 1996 useful application of MSWI fly ash in German coal and/or salt mines emerged as an attractive option. Specifically, the application in concrete for construction of walls in coal mines is an economically and environmentally favorable option that suits the Dutch policy with respect to MSWI fly ash (useful application). Early in 1997 a request for an export permit for this option was granted by the Dutch government. However, the government regards the use of MSWI fly ash in salt mines as a material for filling obsolete mine galleries as disposal. Consequently, no permits for the export MSWI fly ash for use in salt mines in this manner will be granted.

7. POLICY FOR MSWI FLUE GAS SCRUBBING RESIDUES

Again we refer to the 'Policy Paper MSWI residues', in which the following policy for MSWI flue gas scrubbing residues is formulated:

1. At present no options for practical use.
2. Research of the options for re-use of the salt fraction in APC residues.
3. Explore the options for quality improvement so that disposal in landfills as a C3-type waste is made possible.

At the present time, no regulatory demand for quality improvement has been formulated. The high costs for disposal of C2 wastes, however, represents a financial incentive for improving the quality to C3 waste.

8. PRACTICE OF MSWI FLUE GAS SCRUBBING RESIDUES

8.1 Production and subsequent landfill

In 1989 the Dutch incineration emissions guideline 'Richtlijn Verbranden '89' was formulated. Subsequently, this guideline was changed into the 'Decree Air Emissions Waste Incineration'. This Decree came directly into force for new MSWI facilities on February 21, 1993. Existing plants were given until January 1, 1995 to comply with the emission limits stated in this directive. In order to meet these regulations, the flue gas scrubbing system in a typical Dutch MSWI facility currently contains:

- one or more dust removal systems (usually ESP, sometimes fabric filters),
- a 2-stage wet scrubbing system,
- an activated cokes or activated carbon system
- either a catalytic or a non-catalytic DeNO_x-process.

As a result, heavy metals are washed out of the flue gases using water (and the chemicals dissolved therein) and end up in a filter cake: ca. 3 kg per ton of waste. Acid components in the flue gases such as HCl and SO₂ are neutralized and subsequently discharged into surface water. Alternatively, this waste water is spray dried, producing approximately 15 kg of dry salt. In other words: the implementation of flue gas scrubbing is directly reflected in the production of solid residues. This is depicted in Figure 7.

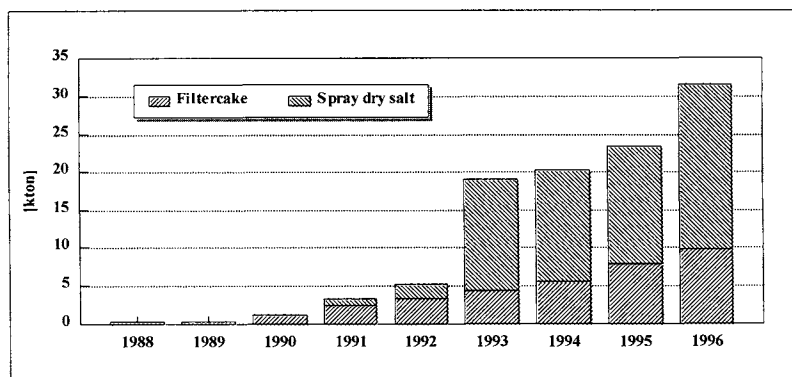


Figure 7 Production of flue gas scrubbing residues

8.2 Treatment of flue gas scrubbing residues

To date, there is no practical use for flue gas scrubbing residues. This is in part a result of the fact that this relatively new material is unknown. Moreover, the residues contain high levels of leachable contaminants and lack a matrix that has the physical strength to be exploited. Because these residues are the precipitated reaction products resulting from water treatment (water discharged by the wet flue gas scrubbers), their leaching behavior is only moderate compared to that of MSWI fly ash. Flue gas scrubbing residues are therefore categorized partly as C2 and partly as C3 hazardous waste. With respect to treatment of MSWI flue gas residues, the following options are considered:

Solidification

The current initiatives for treatment of MSWI flue gas residues aim towards reducing the leaching behavior of the filter cake using solidification techniques with subsequent disposal at C3 landfill sites. A description of this technique has been given for fly ash. Currently, only the disposal of treated residues is considered.

Purifying and discharging the salts

Those MSWIs that are not allowed to discharge their waste water make use of spray-drying techniques. Spray-drying results in a product that consists primarily of salts. Upon spray-drying, the waste water is injected into hot (raw) flue gas. The raw flue gases contaminate the resulting dry salt with heavy metals. A subject of current investigation is the manner in which this product could be separated into a clean salt fraction and a contaminated filter cake containing heavy metals. Materials with a high soluble salt content, such as flue gas scrubbing residues, can be desalted by washing. Two options are available:

- washing of salts and simultaneous or subsequent removal of specific contaminants to allow discharge of a clean salt solution into the sea;
- selective washing of salts and beneficial practical application of the salt (CaCl_2).

The feasibility of both of these options is not yet clear. In any case, it is crucial that an acceptable solution for the discharge of salt water be found. It also has become apparent that there is a global abundance of CaCl_2 . Any production of purified CaCl_2 out of flue gas scrubbing residues will probably result in additional discharge of this salt into the sea somewhere else.

9 CONCLUDING REMARKS

In the Netherlands, the policy for MSWI residues has been agreed upon by all parties involved. This policy has been formalized in a 'Policy Paper MSWI residues'. The current and future practice with respect to use, disposal in landfills and treatment of MSWI residues is monitored in order to verify that it develops in accordance with the policy as determined. The monitoring is performed by a specific project organization (ACR), which also facilitates frequent meetings of the parties involved. During these meetings, the parties responsible for acting on proposals laid down in the Policy Paper report their progress to the other parties.

In summary, not only has a policy been put forward but also an organization has been founded to ensure that this policy is put in practice, or modified where necessary based on a possible new and common understanding of all the parties involved.

10 REFERENCES

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