RADIATION FOR A CLEAN ENVIRONMENT

1975

PROCEEDINGS SERIES

RADIATION FOR A CLEAN ENVIRONMENT

PROCEEDINGS OF THE
INTERNATIONAL SYMPOSIUM ON
THE USE OF HIGH-LEVEL RADIATION
IN WASTE TREATMENT – STATUS AND PROSPECTS
ORGANIZED BY THE
INTERNATIONAL ATOMIC ENERGY AGENCY
AND HELD IN MUNICH
17-21 MARCH 1975

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 1975

RADIATION FOR A CLEAN ENVIRONMENT
IAEA, VIENNA, 1975
STI/PUB/402
ISBN 92-0-060075-1

FOREWORD

For some time the use of ionizing radiation has been envisaged as a means of solving some of the problems of treating municipal and industrial wastes. Some areas where radiation has been considered to offer some promise are: the reduction of organic pollutants; the disinfection of water supplies and waste-water; the disinfection of sludges and the modification of their physical properties, e.g. their sedimentation rate. However, economic considerations militated against any overwhelming enthusiasm for early major applications on these lines.

Recently, however, there has been a significant change in the world energy situation. The cost of oil has increased and the projected role of nuclear power has expanded, in turn affecting the analysis of the economic feasibility of the ionizing radiation treatment of wastes. In addition, consideration for the quality of the environment not only calls for the re-evaluation of conventional waste treatment technologies in the light of their own impact upon the environment, but also for the development of more effective means of waste treatment where conventional methods might be unsatisfactory. With these factors in mind it seemed necessary and timely to review the status of research and development in this subject, and to consider the environmental implications of the proposed technology.

Accordingly, a symposium was convened in Munich by the International Atomic Energy Agency, in co-operation with the Government of the Federal Republic of Germany and the Bayerische Landesanstalt für Bodenkultur und Pflanzenbau, from 17 to 21 March 1975. The symposium, on the Use of High Level Radiation in Waste Treatment – Status and Prospects, was attended by 160 participants from 26 Member States and by representatives of two international organizations. Forty-eight papers were presented in eight sessions covering the current technology of waste-water treatment and re-use, radiosensitivity of micro-organisms, disinfection and microbiological control, physical and chemical modification of aqueous pollutants, technological and economic aspects, pilot plant design and operating experience, and radiation treatment of non-liquid wastes. In the final panel session a summary of the previous sessions was presented, followed by discussions on future prospects and lines of development, with emphasis on sewage water and sludge processing, its feasibility, and the research and development needed to promote it.

The full texts of all the papers and discussions, and an edited summary of the panel discussion are published in this volume. It is hoped that the Proceedings will be used as a primary reference work on the subject.

The Agency gratefully acknowledges the assistance and co-operation of the authorities of the Federal Republic of Germany for acting as host and providing the excellent facilities that helped greatly towards the success of the meeting.

EDITORIAL NOTE

The papers and discussions have been edited by the editorial staff of the International Atomic Energy Agency to the extent considered necessary for the reader's assistance. The views expressed and the general style adopted remain, however, the responsibility of the named authors or participants. In addition, the views are not necessarily those of the governments of the nominating Member States or of the nominating organizations.

Where papers have been incorporated into these Proceedings without resetting by the Agency, this has been done with the knowledge of the authors and their government authorities, and their cooperation is gratefully acknowledged. The Proceedings have been printed by composition typing and photo-offset lithography. Within the limitations imposed by this method, every effort has been made to maintain a high editorial standard, in particular to achieve, wherever practicable, consistency of units and symbols and conformity to the standards recommended by competent international bodies.

The use in these Proceedings of particular designations of countries or territories does not imply any judgement by the publisher, the IAEA, as to the legal status of such countries or territories, of their authorities and institutions or of the delimitation of their boundaries.

The mention of specific companies or of their products or brand names does not imply any endorsement or recommendation on the part of the IAEA.

Authors are themselves responsible for obtaining the necessary permission to reproduce copyright material from other sources.

CONTENTS

DISINFECTION AND MICROBIOLOGICAL CONTROL (Session 3)

PHYSICAL AND CHEMICAL MODIFICATION OF AQUEOUS POLLUTANTS (Session 4)

TECHNOLOGICAL AND ECONOMIC ASPECTS (Session 5)

PILOT PLANT DESIGN AND OPERATING EXPERIENCES (Session 6)

RADIATION TREATMENT OF NON-LIQUID WASTES (Session 7)

REVIEW SERIES 1

CURRENT TECHNOLOGY OF WASTE-WATER TREATMENT AND RE-USE

(Session 1)

Review paper

TYPES AND TREATMENT OF SEWAGE SLUDGES
Practice in the Federal Republic of Germany

M. O. TABASARAN
Institut für Siedlungswasserbau und Wassergütewirtschaft,
University of Stuttgart,
Stuttgart,
Federal Republic of Germany

Abstract

TYPES AND TREATMENT OF SEWAGE SLUDGES: PRACTICE IN THE FEDERAL REPUBLIC OF GERMANY.

The sludge that is formed by the various processes in the sewage treatment plant consists mainly of water with a small amount of organic and inorganic suspended solids. It contains pathogenic agents and biological inhibitors, and must be prepared and brought into a form where it is less dangerous to the environment. The de-watering of the sludge is the first step in sludge handling. The solids content of the raw sludge, which is usually between 5 and 10%, can be increased by gravity thickening to 15%, by centrifuging or straining-band-pressing up to 30%, and by pressure-filtration up to 40%. The process of drying enables a substance with almost no moisture to be obtained. Generally the sludge will be either mixed before de-watering with coagulation agencies, or preheated, or its colloidal components biochemically oxidized in order to accelerate the withdrawal of the water. One of the most common methods of disposal is the transport of sludge to a land filling, usually together with the solid refuse of the community. For this purpose the moisture content of the sludge should not be more than 60 to 70%. The disposal of sludge into the sea can be practised in coastal towns, but the ecological effects of this kind of sludge removal are still disputed. More expedient is the agricultural utilization of sludge, particularly if the sludge is composted together with a carbon carrier such as city refuse which would make it a very suitable soil improver. In the Federal Republic of Germany the wet oxidation of sludge is applied in a few cases. The most common process is anaerobic alkaline digestion. The incineration of sludge is more economical than drying, but still too expensive in comparison with other approved processes.

1. INTRODUCTION

As a result of sewage treatment part of the solids will be retained in the form of sludge. The quantity and specific characteristics of the sludge are influenced by the type of sewage, the treatment applied and the efficiency of such treatment.

The sewage sludge consists of a relatively large amount of water and some solids. The solids are of an organic and inorganic nature.

Depending on its origin, sludge can be classified as domestic and industrial sludge.

1.1. Domestic sludge

Average quantities of domestic sludge are shown in Table I according to the treatment applied. Table I shows that the specific quantity of sludge fluctuates between 0.7 and 3.0 litres/capita daily, the water content between 90 and 97% by weight and the amount of organic solids in the total solids varies between 45 and 80%.

TABLE I. QUANTITIES OF DOMESTIC SLUDGE

Type of sludge	Sludge quantity (litres/capita daily)	Water content (Weight%)	Solids content (Weight%)	Organic solids (Weight%)	Inorganic solids (Weight%)
Raw sludge from primary sedimentation tanks	0.7 - 1.0	92-95	8-5	80-60	20-40
Low-rate trickling filter plant	0.7 - 0.9	90-92	10-8		
High-rate trickling filter plant	1.0 - 1.6	93-95	7-5		
Activated sludge plant	2.1 - 3.0	96-97	4-3	75-62	25-38
Digested sludge	0.5 - 0.8	90-93	10-7	60-45	40-55

TABLE II. PARAMETERS FOR THE DETERMINATION OF SLUDGE CHARACTERISTICS

1. Solids or water content
2. Incineration-residue or incineration loss
3. Organic carbon content
4. Specific gravity
5. Settling properties
6. De-waterability
7. Specific filter resistance
8. Compressibility
9. Grain composition
10. Hydrogen ion concentration
11. Acid consumption
12. Caloric value
13. Viscosity

The sewage sludge looks slimy and unsavoury. It contains an objectionable amount of pathogenic agents causing enteritis, hepatitis, anthrax, paratyphoid fever, poliomyelitis, tuberculosis, typhoid fever and worm diseases of all types.

1.2. Industrial sludge

Quantity and composition of industrial sludge varies in wide ranges depending on the type and nature of industrial production. Type and quantity of the by-products produced and a possible recirculation of industrial water will influence the volume and the condition of the sludge.

Numerous industrial waste-waters contain biological inhibitors. In the metal-working industry poisonous heavy metal ions like lead, cadmium, iron, copper, nickel, mercury, zinc and tin, and also cyanides, chromates, free acids and lyes occur. There are also chlorides, nitrites and sulphates, and sometimes even oil emulsions, lubricants and solvents.

Part of these substances is decomposed or converted in the sewage treatment plant. The rest appears in the sludge. The toxic effect which these substances have on biochemical processes can add or multiply.

1.3. Sludge characteristics

To be able to determine the probable behaviour of a certain sludge during treatment or to compare several different sludges with each other, attempts are made to identify the sludge characteristics by defined parameters. Some of the most important of these parameters are listed in Table II.

2. DE-WATERING OF SLUDGE

As a rule, de-watering constitutes the first step of sludge handling. The lower its water content, the easier its further treatment. By reducing the water content the sludge volume is reduced (see Fig.1). Sludge with a solids content of 5% has a weight of 20 kg subject to a solids weight of 1 kg. After de-watering, say to 40% solids, the same sludge will weigh only 2.5 kg. Thus an increase in solids content from 5 to 40% results in reduction of sludge weight or sludge volume by seven eighths.

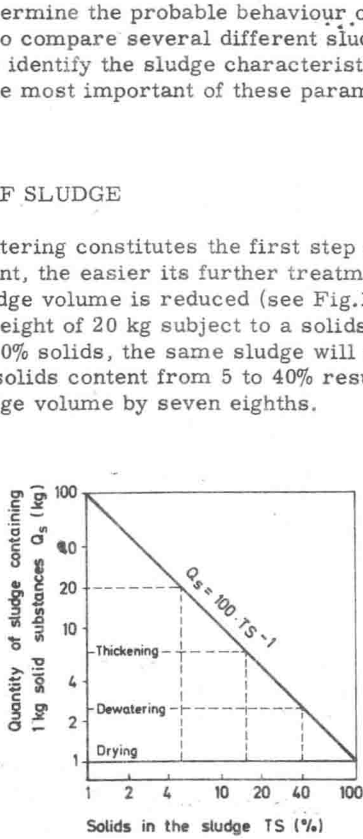

FIG.1. Sludge quantity depending on the solids content.

Adherence forces of different amplitudes prevail between the water and the solids in the sludge. The energy required for de-watering stands in a direct relation to the solids concentration desired. The following technical terms apply to the de-watering:

	Increase of solids from (% by weight)	content to (% by weight)	Sludge condition
(a) Thickening	5	15	Fluid and pumpable
(b) De-watering	15	50	Puncture-proof to crumbling
(c) Drying	50	100	Scatterable to dust-like

2.1. Improvement of the de-watering properties of sludge

The following methods have been found to increase the speed and extent of sludge de-watering.

(a) Sludge blending
(b) Sludge washing
(c) Coagulation of sludge with metal salts, polymers, sludge ashes or thermal energy
(d) Biological treatment.

2.1.1. Sludge blending

The finer sludge is mixed with the coarser sludge so as to change the grain structure and to increase the solids concentration. The finest suspended substances are adsorbed by the larger flakes and the possibility of sludge thickening is enhanced.

When blending a sludge with a solids content of f = 5% with a surplus sludge of f = 2.5% solids content, a blend is produced having a solids content of f = 7%.

2.1.2. Sludge washing

The washing of sludge removes finer solids, thereby improving the grain structure. In addition, the nitrogen compounds are washed out as well with the consequence that less filtering agents are required for coagulation.

2.1.3. Sludge coagulation

Grain size and grain distribution can also be changed by coagulation where smaller particles unite to form larger flakes. Coagulation by electric current, intensified agitation or vibration, etc., is practised in rare cases only. Usually, electrolytes or characteristic or heterogenous ashes are added for this purpose.

2.1.3.1. Coagulation by metal salts. The electrolytes are capable of making up for and balancing the electrostatic charge of the colloids. In practice, predominantly metal salts such as iron sulphates, aluminium sulphates or aluminium chlorides are used.

The conventional electrolytes have recently been supplemented by a number of polymers which have found increased use for the de-watering of sludge.

2.1.3.2. Coagulation by polymers. Polymers are synthetic flocculation agents. They embody linear water-soluble molecules having molecular weights up to approx. 12 million. A chemical reaction (polymerization) produces very long-chain molecules.

The most important effects that polymers have on sludge de-watering are the following:

(a) The de-watering speed is considerably increased. Therefore, the efficiency of de-watering aggregates can be increased considerably. There is, however, no increase in the potential solids content.
(b) The most effective coagulation below optimal polymer batching can be reached only if the polymer is mixed with the sludge for a certain period. By contrast, when using an optimal amount of polymer, the mixing time is almost of no importance at all. In practice, the optimal quantity of polymers is never added and therefore the most favourable mixing times are mandatory.
(c) The amount of polymer exercises a great influence on the filtration speed, the specific filter resistance and the compressibility. The best flake formation and fastest de-watering are obtained subject to a certain fixed ratio of polymer to sludge solids, the relation of which changes with the type of sludge available. The flakes thereby produced are, however, easily compressible which in turn leads to a relatively high compressibility coefficient. In cases such as this the application of very high pressures would no longer be valuable.
(d) The filtrate pollution is rather high and increases in relation to the polymer batching. Therefore particular attention should be paid to the additional load imposed upon the treatment plant.

2.1.3.3. Coagulation by ashes. As a rule, during de-watering the compressibility of the solids content of the sludge impairs complete utilization of higher pressures to separate the liquid from the solid phase. By the admixture of mineral solids, e.g. sludge ashes, it is possible to improve the stability and increase the volume of the sludge cavities.

The specific filter resistance and the compressibility of the sludge are reduced as the amount of ash added is increased. The de-waterability of the sludge-ash blend is, however, not always improved indefinitely. It should be kept in mind that a certain definite mixing ratio yields most favourable results. This is due to the fact that the ashes will absorb part of the water and that the water absorbed by the ash will be very difficult to remove. The de-waterability subject to increased ash batching will be improved up to the point where the effect of water absorption of the ash balances the effect of the lower specific filter resistance. If pressure is applied, the filtration speed at increasing ash quantities will increase even though the total amount of water drained becomes less. As the ash content of the sludge to be de-watered increases, the solids content at the end of the de-watering process naturally increases as well. The residual water quantities therefore increase in the same way as the quantities of sludge cake increase. This means that an increased addition of characteristic ash to the sludge in the incinerator