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on Existing Chemicals of
Environmental Relevance (BUA)

Nitrobenzene
BUA Report 59
(January 1991)



S. Hirzel

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of Environmental Relevance

Beratergremium für
Umweltrelevante Altstoffe (BUA)



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Foreword

The German Chemicals Act (Chemikaliengesetz - ChemG) of 1980 stipulates that certain existing chemicals must be reported to the competent authority, if they exhibit properties which indicate that they may be hazardous, either alone or in combination with other substances.

In the summer of 1982, an Advisory Committee on Existing Chemicals of Environmental Relevance (BUA) was set up by the German Chemical Society (Gesellschaft Deutscher Chemiker - GDCh). It brings together representatives from the scientific community, the chemical industry and the governmental authorities. This Advisory Committee is responsible for elaborating appropriate solutions for substances of relevance for health and the environment on the basis of voluntary measures. It selects and examines existing chemicals from the aforementioned angles. The testing and evaluation are based on scientific criteria alone.

It was, therefore, necessary to develop priority setting procedures. In a first phase reports were only prepared for priority chemicals. Within the framework of a first priority setting procedure, chemicals were compiled from several priority lists and 135 chemicals were selected for detailed substance reports.

In a second priority setting procedure the survey of the German Chemical Industry Association (VCI) on all substances with a production volume of more than 10 tons per year was used as a starting list. Since this survey covered 4,600 chemicals, BUA decided to process the corresponding list in several stages. The first stage included approx. 1,050 substances with a production volume of more than 1,000 tons per year.

Detailed reports are drawn up on chemicals suspected of having a hazard potential and abridged reports on those presenting only a minor hazard potential, according to the current state of knowledge.

The detailed BUA reports take in both the published literature and data from industry. If data for the evaluation of the chemicals are not available, additional studies are recommended and the results are published as updates to the reports. The reports serve as a basis for the instigation of administrative measures, when there are indications of risks to health or the environment.

Tübingen, May 1993

Ernst Bayer
Chairman of the Advisory Committee
on Existing Chemicals
of Environmental Relevance

Contents

Summary and conclusions	IX
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Recommendations	XIV
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Nitrobenzene

1	Chemistry of the substance	1
1.1	Chemical identity	1
1.2	Chemical properties	2
1.3	Composition of the industrial product	5
2	Physical properties	6
3	Analytical methods	8
3.1	Determination in air	8
3.2	Determination in water	9
3.3	Determination in soil, sediment and biological material	10
4	Discharge to the environment during manufacture, processing, usage and waste disposal	11
4.1	Manufacturing and processing	11
4.2	Manufacturers, production levels, exports, imports	12
4.3	Processing and usage	14
4.4	Discharge via wastewater	18
4.4.1	Discharge during manufacture and processing	18
4.4.1.1	Discharge during manufacture	18
4.4.1.2	Discharge during processing	18
4.4.2	Discharge during usage	19
4.5	Discharge via waste air	20
4.5.1	Discharge during manufacture and processing	20
4.5.2	Discharge during usage	21
4.5.3	Discharge from other sources	21
4.6	Discharge to the geosphere and biosphere	21
4.7	Discharge via waste and waste disposal	21
4.8	Summary of discharge into the environment	24
5	Occurrence in the environment	25
5.1	Atmosphere	25
5.2	Hydrosphere	25
5.3	Geosphere	29
5.4	Biosphere	29

6	Behaviour in the environment	30
6.1	Transformation, degradation and degradation products	30
6.1.1	Biodegradation	30
6.1.2	Hydrolytic degradation	36
6.1.3	Photochemical degradation in air and water	36
6.2	Accumulation	38
6.2.1	Bioaccumulation	38
6.2.2	Geoaccumulation	39
6.3	Distribution behaviour and transport processes in and between environmental compartments	39
6.3.1	Henry's constant	39
6.3.2	Soil-sorption coefficients	39
6.4	Fate in the environment	41
7	Ecotoxicology	43
7.1	Effects on aquatic life	43
7.1.1	Micro-organisms	43
7.1.2	Plants	44
7.1.3	Invertebrates	45
7.1.4	Vertebrates	46
7.2	Effects on terrestrial life	47
7.2.1	Micro-organisms	47
7.2.2	Plants	47
7.2.3	Invertebrates	48
7.2.4	Vertebrates	48
8	Toxicity to mammals	49
8.1	General nature of effects	49
8.2	Mode of action	49
8.3	Metabolism, toxicokinetics	50
8.3.1	Animals	50
8.3.2	Man	54
8.3.3	In vitro studies	55
8.4	Acute and subacute toxicity	56
8.5	Compatibility with skin and mucous membranes	58
8.6	Sensitization	58
8.7	Subchronic and chronic toxicity	58
8.8	Genotoxicity	59
8.9	Carcinogenicity	60
8.10	Reproduction toxicity	61
8.10.1	Embryotoxic effects	61
8.10.2	Fertility	62
8.11	Effects on the immune system	64
8.12	Miscellaneous effects	64

8.12.1	Damage to the blood	64
8.12.2	Neurotoxic effects	68
8.12.3	Liver and kidney toxicity.....	69
8.12.4	Effect on tumours	70
8.13	Experience in man	70
8.13.1	Acute intoxication	70
8.13.2	Chronic intoxication	71
8.13.3	Epidemiological data	71
9	Substance-specific legal regulations	72
10	Literature	76

BUA Report on Nitrobenzene

Summary and conclusions

Ecological aspects

Production and use

In 1989, the amount of nitrobenzene produced in the Federal Republic of Germany was approx. 200 000 tonnes, in Western Europe, in 1986, approx. 540 000 tonnes. In the Federal Republic of Germany, approx. 93 % of the nitrobenzene is used for producing aniline. It is furthermore used for preparing dinitrobenzenes (3.0 %), m-chloronitrobenzene (0.8 %) and nitrobenzenesulfonic acid (2.8 %), and also as solvent. The total processed amount in the Federal Republic of Germany runs to about 250 000 t/a.

Emissions into the environment

Emissions from industrial production and manufacture into the environment take place via waste water and via waste air.

The emissions from production, manufacture and application in the Federal Republic of Germany from known industrial sites into the water can be estimated at approx. 12 t/a, and the emission via the waste air at approx. 8 t/a. If waste gases containing nitrobenzene are subjected to oxidative after-burnage, the organic nitrogen is converted mainly into NO_x.

Occurrence in the environment

Due to the physicochemical properties, most of the nitrobenzene emitted into the environment probably occurs in the hydrosphere (about 60 %), and some more in the air (about 35 %).

X

The measured nitrobenzene concentration of air in the USA in residential areas and in industrial areas amounts up to 29.2 $\mu\text{g}/\text{m}^3$. Measurements from the Federal Republic of Germany are not available.

Between 1984 and 1988, the data determined in surface waters in the Federal Republic of Germany (River Rhine) were generally below 1.6 $\mu\text{g}/\text{l}$, the range of variation being 0.02 - 4.7 $\mu\text{g}/\text{l}$.

Biodegradation

The various investigations into the microbial degradation of nitrobenzene revealed that nitrobenzene degradation by non-adapted microorganisms is only small, or none at all. In contrast, degrees of elimination of up to 100 % were achieved when adapted microorganisms were used, in particular in industrial biological treatment plants. In a respirometric test, it was shown that nitrobenzene is, in principle, biodegradable. In addition, the results suggested mineralization.

The reaction mechanisms involved are assumed to comprise elimination of the nitro group in the form of nitrite or ammonia, conversion into phenol, and subsequent cleavage of the aromatic ring. Below a certain threshold concentration, no further substantial degradation is observed, which results in a relatively constant, low nitrobenzene concentration in surface waters. In contrast, higher loads of nitrobenzene, which are clearly above the concentrations which usually occur in treatment plants, obviously exceed the nitrobenzene-specific degradation capacity of activated sludge of adapted biological treatment plants, so that this sludge is not capable of microbially degrading the entire amount of nitrobenzene occurring.

Abiotic degradation

Hydrolysis cannot be expected under prevailing environmental conditions.

The photochemical degradation in the air by ozone proceeds slowly (half-life period at least 2 years). For the reaction with hydroxyl radicals a half-life period of 3 - 17 weeks was calculated. This means that these two reaction routes contribute practically nothing to the elimination of nitrobenzene from the environment.

For the photolytic degradation in water, half-lives of some months were calculated, at least 25 days were required for reactions with hydroxyl radicals in the upper layers of surface waters. Also these degradation pathways are of minor relevance for the environment.

Accumulation

Due to the n-octanol/water distribution coefficient of 1.59 - 2.0, a considerable accumulation in organisms is not to be expected.

The adsorption of nitrobenzene by the soil is only moderate. It depends on the content of the organic carbon of the soil.

Ecotoxicological effects

The toxic limit concentrations in the cell multiplication inhibition test were 7 mg/l (16 h) for *Pseudomonas putida* and 1.9 mg/l (8 d) for the cyanobacterium *Microcystis aeruginosa*. Inhibition of the glucose degradation starts at 30 mg/l (TLC).

XII

Nitrobenzene (100 mg/l) inhibited the oxygen uptake of phenol-adapted mixed cultures by 40 % (test duration: 170 min.). In municipal activated sludge, the respiration of the bacteria stops at a concentration of 1 g/l. Already 100 mg/l results in a noticeable respiration inhibition.

Nitrobenzene at a concentration of 5 - 10 mg/l inhibits the nitrification, and more than 10 mg/l stops it.

Toxic limit concentration values between 1.9 (72 h) and 17 mg/l (48 h) and EC₅₀ values of 98 mg/l were found in the cell multiplication inhibition test in the case of protozoa.

The EC₅₀ values for freshwater algae and sea water algae were between 10 and 44 mg/l (96 h), those for invertebrates (with the exception of *Daphnia magna*) between 6.7 and 850 mg/l, those for *Daphnia magna* between 27 and 62 mg/l (48 h), NOEC (24 h): 0,46 mg/l. For fish the LC₅₀ values were \geq 20 mg/l.

In the reproduction test (21 d) with *Daphnia magna* the NOEC values were between 1.9 and 2.6 mg/l.

Toxicological aspect

Nitrobenzene is rapidly reabsorbed via the respiratory passages and the skin, but eliminated slowly.

In humans, nitrobenzene is metabolized to p-aminophenol and p-nitrophenol and excreted via the urine.

In addition to the metabolites found in humans (only the above mentioned ones were investigated), nitrosobenzene was detected in cats and m-nitrophenol, p-hydroxyacetanilide, m- and o-aminophenol, traces of 4-nitrocatechol, aniline, nitroquinone, unmodified nitrobenzene and two other unidentifiable metabolites in rats and mice. Species-specific differences and, in the case of rats, differences between individual strains, became apparent. Most of the metabolites were excreted as sulfate conjugates. The intestinal flora plays an important role in the reduction of nitrobenzene.

In animal experiments, a single administration of high doses resulted in neurological symptoms and unconsciousness.

Nitrobenzene is slightly irritating to skin and eyes. Information about sensitization is not available.

Several administrations of nitrobenzene resulted in enlargement of liver and kidneys combined with degenerative modifications in both Organs. An enlargement of the spleen, which was already observed at very low doses, was attributed to damage to the erythrocytes due to formation of methemoglobin. Another result was damage to the testicles combined with a disorder in spermatogenesis. Lethal doses of nitrobenzene resulted in brain hemorrhage. Uptake by inhaling provoked Irritation of the mucous membranes.

In a number of Ames tests with various strains and with and without metabolic activation, nitrobenzene was mutagenic only in the presence of norharmane and S9 mix. An effect on the frequency of sister chromatid exchange was not observed. A DNA repair test and a cell transformation test were negative. Short-term tests of little validity gave inconsistent results.

Long-term studies on the carcinogenicity are hitherto unpublished.

Nitrobenzene leads to a degeneration of the germinative epithelium of the testicles, resulting in a lower fertility index. Embryotoxic or teratogenic effects were not observed.

In acute and chronic cases of poisoning in humans, the formation of methemoglobin, Heinz bodies and sulfhemoglobin, cyanosis, unconsciousness and enlargement of liver and kidneys were observed.

Recommendations

Ecotoxicology

Data on the occurrence in the air should be provided.

Toxicology

More investigations are necessary to clarify the genotoxic effects. However, a detailed experimental set-up should not be designed before the results from the CIIT-study, which is completed but has not been published, are available.

Another uninvestigated aspect is the sensitizing effect. However since the substance has been handled for many years and nothing has been published about a sensitizing effect, an experimental study of this effect can be dispensed with.