

Contents

Summary XVII

Introduction 1

1 Methodological Foundations of Defining Environmental Standards 5

1.1 Environmental Standards and Human Attitudes to Nature 5

1.1.1 Environmental Standards as Cultural Achievements 6

1.1.2 Setting Limit Values as a Rational Process 10

1.1.3 Pragmatic Consistency and Practical Generalizability 14

1.2 Methodological Problems of Establishing Limit Values 18

1.2.1 The Effect Principle 18

1.2.2 Natural Exposures 23

1.2.3 Combined Effects 25

1.3 Environmental Policy 28

1.3.1 The Risk Concept as a Fundamental Concept of Environmental Policy 28

1.3.2 Principles of Environmental Policy 31

1.3.3 Instruments of Environmental Policy 34

1.4 Literature 35

2 Scientific and Medical Foundations 39

2.1 Possible Principles of Interaction between two Noxae, especially with the Involvement of Ionizing Radiation 41

2.2 Dose-Response Relationships and Models for Combined Effects 41

2.2.1 Dose-Response Curves and Mechanisms 41

2.2.1.1 Reversible Effect Mechanisms 43

2.2.1.2 Irreversible Mechanisms 45

2.2.1.3 Mutagenic Effects 46

2.2.1.4 Tumours 48

2.2.1.5	Dose-Response Curves in the Lower Dose Range	50
2.2.1.6	Differentiation between Stochastic and Non-stochastic Effects	54
2.2.1.7	Conclusions	55
2.2.2	Combined Effects	56
2.2.2.1	Terminology	56
2.2.2.2	Comparison with Single Effects: Synergism and Antagonism	56
2.2.2.3	Comparison with Models	57
2.2.2.4	Toxicokinetic and Toxicodynamic Interactions	58
2.2.2.5	Representation of Combined Effects	58
2.2.2.6	Models for Combined Effects	60
2.2.2.7	The Importance of the Independence Model	65
2.2.2.8	Independent Effects of Different Kinds	66
2.2.2.9	Combinations of Stochastic Effects	66
2.2.2.10	Combinations of Non-stochastic Effects	68
2.2.2.11	Non-mechanistic Models	71
2.2.2.12	Dose Additivity for Agents Behaving Differently	74
2.2.2.13	Stochastic and Non-stochastic Effects in Combination	74
2.2.2.14	Non-stochastic Multiple Combinations	75
2.2.2.15	Stochastic Multiple Combinations	77
2.2.2.16	Stochastic and Non-stochastic Multiple Combinations	77
2.2.3	Examples of Empirical Combined Effects	78
2.2.3.1	Interactions between Medicinal Drugs: Mechanisms, Extent and Incidence	78
2.2.3.2	Dose-Response Analyses	79
2.2.3.3	Effect Amplification in the Lower Dose Range?	85
2.2.3.4	Reduction of a Threshold Dose of A in the Presence of B?	86
2.2.3.5	Slope Values of Dose-Response Curves and their Impact on Amplification Effect in Combination	89
2.2.3.6	Conclusions	89
2.2.4	Literature	91
2.3	Combined Exposure to Radiation and Substances	94
2.3.1	Biological Effects of Ionizing Radiation	94
2.3.1.1	Overview	94
2.3.1.2	The Induction of Malignant Diseases	95
2.3.1.3	Extrapolations	98
2.3.2	Radiation Protection	99
2.3.2.1	Radiation Dose Units	99
2.3.2.2	Radiation Exposure of the Population	100
2.3.2.3	Dose Limits	102

2.3.3	Interactions between Ionizing Radiation and Chemicals	103
2.3.3.1	Basic Considerations on Estimating Combined Effects	103
2.3.3.2	Exemplary Discussion of Combined Effects	105
2.3.3.3	Summary Assessment and Recommendations for Action	133
2.3.4	Literature	141
2.4	Combined Exposure to Chemical Substances	147
2.4.1	Introduction	147
2.4.1.1	The Categorical Heterogeneity of Limit Values	148
2.4.1.2	Problems concerning “Safety Margins”	148
2.4.1.3	Toxicological Systematics of Combined Exposures	150
2.4.1.4	Present Knowledge on Combined Effects	152
2.4.2	Conventionally Toxic Effects	153
2.4.2.1	A Complex, mostly Indefinite Mixture: Love Canal	154
2.4.2.2	A Complex, Definite Mixture: Contaminations in Drinking Water.	157
2.4.2.3	Conclusions	159
2.4.3	Hypotheses on Combined Effects in the Range of “Effect Thresholds”	159
2.4.3.1	Difficulties of Finding Limit Values for Combined Exposures	159
2.4.3.2	Findings Supporting the Hypotheses	161
2.4.3.3	Further Experiments Supporting the Hypotheses	169
2.4.3.4	Apparent Conflicts with the Hypotheses	172
2.4.3.5	Summary and Assessment	179
2.4.3.6	Appendix	181
2.4.3.7	Literature	182
2.4.4	Combined Exposure to Cancerogenic Substances	183
2.4.4.1	Attack Sites and Factors of Influence.	184
2.4.4.2	Establishing the Cancerogenic Properties of Chemical Substances: Epidemiology vs. Experiment	187
2.4.4.3	Results from Epidemiological Studies	188
2.4.4.4	Animal Experiments	193
2.4.4.5	Summary Assessment and Recommendations for Action	210
2.4.4.6	Appendix	212
2.4.4.7	Literature	215

2.5	Quantitative Relationships between Mixed Exposures and Effects on Plants	217
2.5.1	Introduction	217
2.5.2	Establishing Dose-Response Relationships and Evaluating Guideline Values for Single Components	218
2.5.2.1	The Relationship between Exposure and Effect .	218
2.5.2.2	The Present Situation Concerning Immissions of Effects	219
2.5.2.3	Protected Assets	221
2.5.2.4	Criteria for the Detection and Assessment of Effects	222
2.5.2.5	Assessment of the Results regarding their Relevance for Determining Dose-Response Relationships	223
2.5.2.6	Evaluation of the Guideline Values for Single Components	226
2.5.3	Prospects for the Appraisal of the Hazard Potential of Mixed Exposures	239
2.5.3.1	Examples of Combined Effects	240
2.5.3.2	Models for Dose-Response Relationships in Combined Exposure	247
2.5.3.3	Filtered-Unfiltered Experiments	253
2.5.3.4	Possible Interactions	254
2.5.4	Summary Assessment and Recommendations for Action	256
2.5.5	Literatur	259
3	Perception of Technical Risks	265
3.1	Foreword	265
3.2	Current Risk Debate	266
3.3	Risk Perception Models	269
3.3.1	Semantic Risk Model	269
3.3.2	Risk as an Early Warning Indicator	273
3.4	Intuitive Processes of Risk Perception	274
3.5	The Media as a Source of Information	278
3.6	Perception of Combined Effects	280
3.7	Psychosomatic Links	284
3.8	Duties of Risk Policy	286
3.9	Conclusions	289
3.10	Literature	292

4	The Importance of Economic Factors in Setting Combined Environmental Standards	297
4.1	Scope	297
4.2	Cost-effective Environmental Protection with Adequate Information	299
4.2.1	Adverse Effects	299
4.2.2	Abatement Costs	301
4.2.3	Cost-efficient Limit Values	302
4.3	An Empirical Example	306
4.4	Choice of Policy Instruments	307
4.5	Cost-efficient Limit Values under Imperfect Information	310
4.5.1	Uncertainty in Decision-making	310
4.5.2	Stochastic Decision Model	312
4.5.3	Fuzzy Decision Model	314
4.5.4	Decision Models Subject to Uncertainty	316
4.6	Conclusions	317
4.7	Literature	318
5	Legal Problems of Assessing and Regulating Exposure to Combined Effects of Substances and Radiation	321
5.1	The Current Legal Situation	321
5.1.1	Constitutional Duties of Protection	321
5.1.2	Environment Protection Law	322
5.1.2.1	General	322
5.1.2.2	Laws Relating to Environmental Media	323
5.1.2.3	Chemicals Law	325
5.1.3	Secondary Legislation	327
5.1.3.1	General	327
5.1.3.2	Limits	327
5.1.3.3	Action Thresholds Giving Rise to Legal Obligations	332
5.1.3.4	Classification of Mixtures and Preparations	334
5.1.4	Imputation of Combined Effects	338
5.1.4.1	Civil Liability Law	338
5.1.4.2	Welfare Law Pertaining to Occupational Health and Safety	341
5.1.4.3	Public Law	342
5.1.5	Lifestyle-based Substance Risk	345

5.2	The Situation in Other Countries	346
5.2.1	USA	346
5.2.2	Switzerland	349
5.2.3	Netherlands	350
5.3	Appraisal	352
5.3.1	Constitutional Foundations	352
5.3.2	Summary Appraisal of the Current Legal Situation and Reform Needs	354
5.4	Reform Proposals I: Assessment of Combined Effects ...	356
5.4.1	Testing of New Substances	356
5.4.2	Testing of Existing Substances	357
5.4.3	Classification	357
5.4.4	Research Obligations	357
5.4.5	Conclusions	358
5.5	Reform Proposals II: Regulation	359
5.5.1	General	359
5.5.1.1	Limits to the Law in Regulating Combined Effects	359
5.5.1.2	Prevention of Dangers and Precaution Against Hazards	360
5.5.1.3	Environmental Quality, Emission Limits and Minimization	363
5.5.1.4	Conclusions	364
5.5.2	Regulatory Strategies for Combined Effects	364
5.5.2.1	Limits to the Regulatory Coverage of (Possible) Combined Effects	364
5.5.2.2	Regulatory Strategies	365
5.5.2.3	Case-wise Risk Assessment	366
5.5.2.4	Safety Margins	367
5.5.2.5	Dominant Components	368
5.5.2.6	Limits for Combined Effects	368
5.5.2.7	Emission Restrictions and Minimization	370
5.5.3	Policy Addressees (Imputation Models)	372
5.5.3.1	Basic Imputation Models	372
5.5.3.2	Voluntary Model	372
5.5.3.3	Quota Model	373
5.5.3.4	Priority Principle	374
5.5.3.5	Remediation Model	375
5.5.3.6	Dominant Component Model	375
5.5.3.7	Compensatory Model	376
5.5.3.8	General Imputation Principles	376
5.5.3.9	Relationship between Regulatory and Imputation Models	378
5.6	Recommendations	379
5.7	Literature	380

6	Appraisal and Recommendations	387
6.1	Summary Appraisal	387
6.2	Possible Solutions and Recommendations for Action	393
Glossary		397
Authors		405

Environmental Standards

Combined Exposures and Their Effects on Human
Beings and Their Environment

Streffer, C.; Bückner, J.; Cansier, A.; Cansier, D.;
Gethmann, C.F.; Guderian, R.; Hanekamp, G.;
Henschler, D.; Pösch, G.; Rehbinder, E.; Renn, O.;
Slesina, M.; Wuttke, K.

2003, XXXV, 409 p., Hardcover

ISBN: 978-3-540-44097-0