

Table of Contents

1.	Objectives	1
2.	Required Performance	3
2.1	Introduction	3
2.2	Water needs for malting and brewing	4
2.2.1	Introduction	4
2.2.2	Water use in malting	4
2.2.3	Water use in brewing	5
2.3	Role of the quality of water in malting and brewing	7
2.3.1	Water for malting	7
2.3.2	Water for brewing	7
2.3.3	Effects of ions during beer production	9
2.3.4	Requirements for high gravity brewing	14
2.4	Demands on the quality of water for soft drinks, soda water and other bottled waters	15
2.5	Official directives, standards and guidelines	18
3.	Characteristics and sources of water	23
3.1	Introduction	23
3.2	Basic characteristics of water	23
3.2.1	The water molecule	23
3.2.2	Chemical composition	24
3.2.3	Undesirable and toxic substances	31
3.2.4	Sensory properties	31
3.2.5	Microorganisms in water	33
3.3	Sources of water	35
3.3.1	Introduction	35
3.3.2	Surface water	35
3.3.3	Ground water	36
3.3.4	Water from the public supply	40
3.3.5	Brackish and salt water	41
3.3.6	Purified water for re-use	42

4	Water treatment processes	43
4.1	Introduction	43
4.2	Pre-treatment processes	44
4.2.1	Flocculation and coagulation	44
4.2.2	Flotation	47
4.2.3	Sedimentation	48
4.2.4	Filtration	51
4.2.5	Aeration	56
4.3	Main treatment processes	59
4.3.1	Ion exchange	59
4.3.2	Chemical methods	65
4.3.3	Membrane filtration	67
4.3.4	Evaporation	72
4.4	After treatment processes	74
4.4.1	Disinfection, physical methods	74
4.4.2	Disinfection, chemical methods	76
4.4.3	De-aeration	81
4.5	Practical water treatment applications	83
4.5.1	Introduction	83
4.5.2	Ground water treatment	83
4.5.3	Surface water treatment	85
4.5.4	Special treatment	86
5.	Quality management	89
5.1	Introduction	89
5.2	Quality assurance of brewing water	89
5.2.1	Frequent quality checks	89
5.2.2	More extensive examinations	92
5.2.3	Monitoring according to EC Directive (98/83/EC)	93
5.3	HACCP, Hazard Analysis Critical Control Points	95
5.4	Quality management standards, ISO 9000	96
5.5	Environmental standards, ISO 14000	97
6.	The environmentally friendly brewery	99
6.1	Introduction	99
6.2	A specific case study	99
6.2.1	The approach	99

6.2.2	Mass balance for water	100
6.2.3	Waste water characterisation	100
6.2.4	Purification and re-use of malting steep water	103
6.2.5	Treatment of alkaline bottle washing solutions	103
6.2.6	Purification and re-use of rinse water from bottle washing machines	105
6.2.7	Conclusions	107
7.	References	109
Appendix: Case Studies		111
A.1	Case Study 1. The use of nanofiltration at Lapin Kulta Brewery, Tornio, Finland.....	112
A.2	Case Study 2. The treatment of municipal water by carbon filtration and partial softening, Panonska New Brewery, Koprivnica, Croatia.....	115
A.3	Case Study 3. Rapid decarbonisation of well water for brewery process and utility use, Mecklenburgische Brauerei, Lübz, Germany.....	117
A.4	Case Study 4. U.V. sterilisation of well water for use in a traditional ale brewery, Harvey & Sons, Lewes, UK.....	122
A.5	Artificial groundwater to supplement natural sources, Tuusula municipal waterworks, Tuusula, Finland	124
A.6	Treatment by ion exchange of high hardness well water for brewing purposes, Distelhäuser Brauerei, Tauberbischofsheim, Germany.....	127