Sara De Toffol

Ţ

1

Sewer System Performance Assessment – an Indicators Based Methodology

| | xtion | |
|---|--|---|
| 1.1. Ba | ckground | 1 |
| 1.1.1. | Sewer system characterization and historical review | 1 |
| 1.1.2. | Pollution in the sewer system | 4 |
| 1.2. De | sign of the sewer system | 5 |
| 1.3. Ra | in as driving force | 5 |
| 14 As | sessing the sewer system performance by means of simulation | 6 |
| 1.5 Inc | licators | 7 |
| 2 Scope a | nd structure of the dissertation | Q |
| 2.1 Pa | her I | 11 |
| 2.1. Paj | ner II | 11 |
| 2.2. 1 a | 9er 111 | 12 |
| 2.5. Pa | her IV | 12 |
| 2.4. Pa | her V | 12 |
| 2.5. Taj | oer VI | 12 |
| 2.0. Taj | her VII | 13 |
| $\frac{2.7.1a}{3}$ | ackground of sever design | 14 |
| 3. Legard | e European Water Framework Directive | |
| 211 | Introduction | 14 |
| 2.1.1. | Implomentation process | 14 |
| 3.1.2. 2.1.2 | Water badies elegification | |
| 3.1.3. | Combined appreciable | 13 |
| <i>3.1.4.</i> 2.1.5 | Economia inques | 10 |
| 5.1.5. 2.1.6 | Lumburgentation in Austria | 18 |
| 3,1.0. 2.2 Au | implementation in Austria | |
| 3.2. Au | Bagyirement for combined cover everflows for the emission permanah | |
| 5.2.1. | Requirement for combined sewer overflows for the emission approach | |
| 2 2 2 2 | Dequirement for combined server overflows for the emission approach. | |
| 3.2.2. | Requirement for combined sever overflows for the ambient water qual 21 | ity approach |
| 3.2.2. | Requirement for combined server overflows for the ambient water qual 21 | ity approach |
| 3.2.2. 3.3. Ott | Requirement for combined sewer overflows for the ambient water qual 21 her national guidelines on CSO design | ity approach 22 |
| 3.2.2. 3.3. Ott 3.3.1. | Requirement for combined server overflows for the emission approach 21 her national guidelines on CSO design | ity approach 22 in and sewer |
| 3.2.2. 3.3. Ott 3.3.1. systems 3.3.2 | Requirement for combined server overflows for the emission approach Requirement for combined sewer overflows for the ambient water qual 21 her national guidelines on CSO design The approach for CSO design of the European Norm EN 752-4, "Drai outside buildings. Hydraulic design and environmental considerations" Legislation and Technical Guidance on CSO in Germany. | ity approach |
| 3.2.2. 3.3. Ott 3.3.1. systems 3.3.2. 3.3.2 | Requirement for combined sever overflows for the emission approach Requirement for combined sewer overflows for the ambient water qual 21 The approach for CSO design of the European Norm EN 752-4, "Drai outside buildings. Hydraulic design and environmental considerations" Legislation and Technical Guidance on CSO in Germany | ity approach 22 in and sewer 25 25 25 |
| 3.2.2. 3.3. Ott 3.3.1. systems 3.3.2. 3.3.3. 3.3.4 | Requirement for combined sever overflows for the emission approach Requirement for combined sever overflows for the ambient water qual 21 The approach for CSO design of the European Norm EN 752-4, "Drai outside buildings. Hydraulic design and environmental considerations" Legislation and Technical Guidance on CSO in Flanders (Belgium) Legislation and Technical Guidance on CSO in Flanders (Belgium) | ity approach 22 in and sewer 25 26 26 |
| 3.2.2. 3.3. Ott 3.3.1. systems 3.3.2. 3.3.3. 3.3.4. 3.3.5 | Requirement for combined sever overflows for the emission approach Requirement for combined sever overflows for the ambient water qual 21 The approach for CSO design of the European Norm EN 752-4, "Drai outside buildings. Hydraulic design and environmental considerations" Legislation and Technical Guidance on CSO in Flanders (Belgium) Legislation and Technical Guidance on CSO in the USA Legislation and Technical Guidance on CSO in the USA | ity approach 22 in and sewer 25 25 26 26 26 28 |
| 3.2.2. 3.3. Ott 3.3.1. systems 3.3.2. 3.3.3. 3.3.4. 3.3.5. 3.4. Gu | Requirement for combined sever overflows for the emission approach Requirement for combined sever overflows for the ambient water qual 21 The approach for CSO design of the European Norm EN 752-4, "Drai outside buildings. Hydraulic design and environmental considerations" Legislation and Technical Guidance on CSO in Germany Legislation and Technical Guidance on CSO in Flanders (Belgium) Legislation and Technical Guidance on CSO in the USA Legislation and Technical Guidance on CSO in Great Britain | ity approach 22 in and sewer 25 25 26 26 28 28 |
| 3.2.2. 3.3. Ott 3.3.1. systems 3.3.2. 3.3.3. 3.3.4. 3.3.5. 3.4. Gu | Requirement for combined sever overflows for the emission approach Requirement for combined sever overflows for the ambient water qual 21 The approach for CSO design of the European Norm EN 752-4, "Drai outside buildings. Hydraulic design and environmental considerations" Legislation and Technical Guidance on CSO in Germany Legislation and Technical Guidance on CSO in Flanders (Belgium) Legislation and Technical Guidance on CSO in the USA Legislation and Technical Guidance on CSO in Great Britain Legislation and Technical Guidance on CSO in Great Britain idelines on sewer design | ity approach 22 in and sewer 25 25 26 26 28 29 Trulic design |
| 3.2.2. 3.3. Ott 3.3.1. systems 3.3.2. 3.3.3. 3.3.4. 3.3.5. 3.4. Gut 3.4.1. and env | Requirement for combined sever overflows for the emission approach Requirement for combined sever overflows for the ambient water qual 21 The approach for CSO design of the European Norm EN 752-4, "Drai outside buildings. Hydraulic design and environmental considerations" Legislation and Technical Guidance on CSO in Germany Legislation and Technical Guidance on CSO in Flanders (Belgium) Legislation and Technical Guidance on CSO in the USA Legislation and Technical Guidance on CSO in Great Britain Legislation and Technical Guidance on CSO in Great Britain Legislation and Technical Guidance on CSO in Great Britain idelines on sewer design European guideline "Drain and sewer systems outside buildings. Hydr ironmental considerations" EN 752 | ity approach 22 in and sewer 25 26 26 26 26 28 29 raulic design |
| 3.2.2. 3.3. Ott 3.3.1. systems 3.3.2. 3.3.3. 3.3.4. 3.3.5. 3.4. Gu 3.4.1. and env 3.4.2 | Requirement for combined sever overflows for the emission approach Requirement for combined sever overflows for the ambient water qual 21 The approach for CSO design of the European Norm EN 752-4, "Drai outside buildings. Hydraulic design and environmental considerations" Legislation and Technical Guidance on CSO in Germany Legislation and Technical Guidance on CSO in Flanders (Belgium) Legislation and Technical Guidance on CSO in the USA Legislation and Technical Guidance on CSO in Great Britain Legislation and Technical Guidance on CSO in Great Britain Austria Guidaline on cever design | ity approach 22 in and sewer 25 26 26 26 26 28 29 raulic design 29 30 |
| 3.2.2. 3.3. Ott 3.3.1. systems 3.3.2. 3.3.3. 3.3.4. 3.3.5. 3.4. Gu 3.4.1. and env 3.4.2. 3.4.3 | Requirement for combined sever overflows for the emission approach Requirement for combined sever overflows for the ambient water qual 21 The approach for CSO design of the European Norm EN 752-4, "Drai outside buildings. Hydraulic design and environmental considerations". Legislation and Technical Guidance on CSO in Germany Legislation and Technical Guidance on CSO in Flanders (Belgium) Legislation and Technical Guidance on CSO in Flanders (Belgium) Legislation and Technical Guidance on CSO in Great Britain Legislation and Technical Guidance on CSO in Great Britain idelines on sewer design European guideline "Drain and sewer systems outside buildings. Hydr ironmental considerations", EN-752 Austrian guideline on sewer design "ÖWAV Regelblatt 11" Austrian guideline on sever treatment "Bacehlatt 25" | 18 ity approach |
| 3.2.2. 3.3. Ott 3.3.1. systems 3.3.2. 3.3.3. 3.3.4. 3.3.5. 3.4. Gut 3.4.1. and env 3.4.2. 3.4.3. 3.5. Gut | Requirement for combined sever overflows for the emission approach Requirement for combined sever overflows for the ambient water qual 21 The approach for CSO design of the European Norm EN 752-4, "Drai outside buildings. Hydraulic design and environmental considerations". Legislation and Technical Guidance on CSO in Germany Legislation and Technical Guidance on CSO in Flanders (Belgium) Legislation and Technical Guidance on CSO in Flanders (Belgium) Legislation and Technical Guidance on CSO in Great Britain Legislation and Technical Guidance on CSO in Great Britain Austrian guideline "Drain and sewer systems outside buildings. Hydr ironmental considerations", EN-752 Austrian guideline on sewer design "ÖWAV Regelblatt 11" Austrian guideline on stormwater treatment "Regelblatt 35" | ity approach 22 in and sewer 25 26 26 26 28 29 raulic design 29 30 31 31 |
| 3.2.2. 3.3. Ott 3.3.1. systems 3.3.2. 3.3.3. 3.3.4. 3.3.5. 3.4. Gut 3.4.1. and env 3.4.2. 3.4.3. 3.5. Get 3.6. Sut | Requirement for combined sewer overflows for the emission approach Requirement for combined sewer overflows for the ambient water qual 21 The approach for CSO design of the European Norm EN 752-4, "Drai outside buildings. Hydraulic design and environmental considerations". Legislation and Technical Guidance on CSO in Germany. Legislation and Technical Guidance on CSO in Flanders (Belgium). Legislation and Technical Guidance on CSO in Flanders (Belgium). Legislation and Technical Guidance on CSO in Great Britain. Legislation and Technical Guidance on CSO in Great Britain. Austrian guideline "Drain and sewer systems outside buildings. Hydr ironmental considerations", EN-752. Austrian guideline on sewer design "ÖWAV Regelblatt 11". Austrian guideline on stormwater treatment "Regelblatt 35". Trman guideline on rain analysis ATV 121 | ity approach 22 in and sewer 25 26 26 26 26 28 29 raulic design 29 30 31 31 |
| 3.2.2. 3.3. Ott 3.3.1. systems 3.3.2. 3.3.3. 3.3.4. 3.3.5. 3.4. Gu 3.4.1. and env 3.4.2. 3.4.3. 3.5. Ge 3.6. Su | Requirement for combined sewer overflows for the emission approach Requirement for combined sewer overflows for the ambient water qual 21 The approach for CSO design of the European Norm EN 752-4, "Drai outside buildings. Hydraulic design and environmental considerations". Legislation and Technical Guidance on CSO in Germany Legislation and Technical Guidance on CSO in Flanders (Belgium) Legislation and Technical Guidance on CSO in Flanders (Belgium) Legislation and Technical Guidance on CSO in Great Britain Legislation and Technical Guidance on CSO in Great Britain Austrian guideline "Drain and sewer systems outside buildings. Hydr ironmental considerations", EN-752 Austrian guideline on sewer design "ÖWAV Regelblatt 11" Austrian guideline on stormwater treatment "Regelblatt 35" rman guideline on rain analysis ATV 121 | ity approach 22 in and sewer 25 25 26 26 26 28 29 raulic design 29 30 31 31 31 |
| 3.2.2. 3.3. Ott 3.3.1. systems 3.3.2. 3.3.3. 3.3.4. 3.3.5. 3.4. Gu 3.4.1. and env 3.4.2. 3.4.3. 3.5. Ge 3.6. Su 4. Method 4. L. Ut | Requirement for combined sever overflows for the emission approach Requirement for combined sever overflows for the ambient water qual 21 The approach for CSO design of the European Norm EN 752-4, "Drai outside buildings. Hydraulic design and environmental considerations" Legislation and Technical Guidance on CSO in Germany Legislation and Technical Guidance on CSO in Flanders (Belgium) Legislation and Technical Guidance on CSO in Flanders (Belgium) Legislation and Technical Guidance on CSO in Great Britain Legislation and Technical Guidance on CSO in Great Britain European guideline "Drain and sewer systems outside buildings. Hydr ironmental considerations", EN-752 Austrian guideline on sewer design "ÖWAV Regelblatt 11" Austrian guideline on stormwater treatment "Regelblatt 35" rman guideline on rain analysis ATV 121 mmary s and Procedures | ity approach 22 in and sewer 25 26 26 26 26 26 28 29 raulic design 29 30 31 31 31 32 33 |
| 3.2.2. 3.3. Ott 3.3.1. systems 3.3.2. 3.3.3. 3.3.4. 3.3.5. 3.4. Gu 3.4.1. and env 3.4.2. 3.4.3. 3.5. Ge 3.6. Su 4. Method 4.1. Hy | Requirement for combined sever overflows for the emission approach Requirement for combined sever overflows for the ambient water qual 21 The approach for CSO design of the European Norm EN 752-4, "Drai outside buildings. Hydraulic design and environmental considerations". Legislation and Technical Guidance on CSO in Germany Legislation and Technical Guidance on CSO in Flanders (Belgium) Legislation and Technical Guidance on CSO in Flanders (Belgium) Legislation and Technical Guidance on CSO in Great Britain Legislation and Technical Guidance on CSO in Great Britain idelines on sewer design European guideline "Drain and sewer systems outside buildings. Hydr ironmental considerations", EN-752 Austrian guideline on sewer design "ÖWAV Regelblatt 11" Austrian guideline on stormwater treatment "Regelblatt 35" rman guideline on rain analysis ATV 121 mmary. s and Procedures | 18 ity approach |
| 3.2.2. 3.3. Ott 3.3.1. systems 3.3.2. 3.3.3. 3.3.4. 3.3.5. 3.4. Gu 3.4.1. and env 3.4.2. 3.4.3. 3.5. Ge 3.6. Su 4. Method 4.1. Hy 4.1.1. | Requirement for combined sewer overflows for the emission approach Requirement for combined sewer overflows for the ambient water qual 21 her national guidelines on CSO design The approach for CSO design of the European Norm EN 752-4, "Drai outside buildings. Hydraulic design and environmental considerations" Legislation and Technical Guidance on CSO in Germany Legislation and Technical Guidance on CSO in Flanders (Belgium) Legislation and Technical Guidance on CSO in Flanders (Belgium) Legislation and Technical Guidance on CSO in Great Britain Legislation and Technical Guidance on CSO in Great Britain idelines on sewer design European guideline "Drain and sewer systems outside buildings. Hydr ironmental considerations", EN-752 Austrian guideline on sewer design "ÖWAV Regelblatt 11" Austrian guideline on stormwater treatment "Regelblatt 35" rman guideline on rain analysis ATV 121 mmary s and Procedures drological background Rain measurement | 18 ity approach |
| 3.2.2. 3.3. Ott 3.3.1. systems 3.3.2. 3.3.3. 3.3.4. 3.3.5. 3.4. Gu 3.4.1. and env 3.4.2. 3.4.3. 3.5. Ge 3.6. Su 4. Method 4.1. Hy 4.1.1. 4.1.2. 4.1.2 | Requirement for combined sewer overflows for the emission approach Requirement for combined sewer overflows for the ambient water qual 21 her national guidelines on CSO design The approach for CSO design of the European Norm EN 752-4, "Drai outside buildings. Hydraulic design and environmental considerations" Legislation and Technical Guidance on CSO in Germany Legislation and Technical Guidance on CSO in Flanders (Belgium) Legislation and Technical Guidance on CSO in Great Britain Legislation and Technical Guidance on CSO in Great Britain Legislation and Technical Guidance on CSO in Great Britain European guideline "Drain and sewer systems outside buildings. Hydr ironmental considerations", EN-752 Austrian guideline on sewer design "ÖWAV Regelblatt 11" Austrian guideline on stormwater treatment "Regelblatt 35" rman guideline on rain analysis ATV 121 mmary s and Procedures | 18 ity approach |
| 3.2.2. 3.3. Ott 3.3.1. systems 3.3.2. 3.3.3. 3.3.4. 3.3.5. 3.4. Gu 3.4.1. and env 3.4.2. 3.4.3. 3.5. Ge 3.6. Su 4. Method 4.1. Hy 4.1.1. 4.1.2. 4.1.3. 4.1.4 | Requirement for combined sever overflows for the emission approach Requirement for combined sever overflows for the ambient water qual 21 her national guidelines on CSO design The approach for CSO design of the European Norm EN 752-4, "Drai outside buildings. Hydraulic design and environmental considerations" Legislation and Technical Guidance on CSO in Germany Legislation and Technical Guidance on CSO in Flanders (Belgium) Legislation and Technical Guidance on CSO in Flanders (Belgium) Legislation and Technical Guidance on CSO in Great Britain Legislation and Technical Guidance on CSO in Great Britain idelines on sewer design European guideline "Drain and sewer systems outside buildings. Hydr ironmental considerations", EN-752 Austrian guideline on sewer design "ÖWAV Regelblatt 11" Austrian guideline on stormwater treatment "Regelblatt 35" rman guideline on rain analysis ATV 121 mmary s and Procedures drological background Rain measurement. Return period Rain data format. | 18 iity approach |
| 3.2.2. 3.3. Ott 3.3.1. systems 3.3.2. 3.3.3. 3.3.4. 3.3.5. 3.4. Gu 3.4.1. and env 3.4.2. 3.4.3. 3.5. Ge 3.6. Su 4. Method 4.1. Hy 4.1.1. 4.1.2. 4.1.3. 4.1.4. | Requirement for combined sewer overflows for the emission approach Requirement for combined sewer overflows for the ambient water qual 21 her national guidelines on CSO design The approach for CSO design of the European Norm EN 752-4, "Drai outside buildings. Hydraulic design and environmental considerations" Legislation and Technical Guidance on CSO in Germany Legislation and Technical Guidance on CSO in Flanders (Belgium) Legislation and Technical Guidance on CSO in Flanders (Belgium) Legislation and Technical Guidance on CSO in Great Britain Legislation and Technical Guidance on CSO in Great Britain idelines on sewer design European guideline "Drain and sewer systems outside buildings. Hydr ironmental considerations", EN-752 Austrian guideline on sewer design "ÖWAV Regelblatt 11" Austrian guideline on stormwater treatment "Regelblatt 35" rman guideline on rain analysis ATV 121 mmary s and Procedures drological background Rain measurement Return period Rain data format Runoff generation | 18 iity approach |
| 3.2.2. 3.3. Ott 3.3.1. systems 3.3.2. 3.3.3. 3.3.4. 3.3.5. 3.4. Gu 3.4.1. and env 3.4.2. 3.4.3. 3.5. Ge 3.6. Su 4. Method 4.1. Hy 4.1.1. 4.1.2. 4.1.3. 4.1.4. 4.1.5. | Requirement for combined sewer overflows for the emission approach Requirement for combined sewer overflows for the ambient water qual 21 her national guidelines on CSO design The approach for CSO design of the European Norm EN 752-4, "Drai outside buildings. Hydraulic design and environmental considerations" Legislation and Technical Guidance on CSO in Germany Legislation and Technical Guidance on CSO in Flanders (Belgium) Legislation and Technical Guidance on CSO in Flanders (Belgium) Legislation and Technical Guidance on CSO in Great Britain Legislation and Technical Guidance on CSO in Great Britain idelines on sewer design European guideline "Drain and sewer systems outside buildings. Hydr ironmental considerations", EN-752 Austrian guideline on sewer design "ÖWAV Regelblatt 11" Austrian guideline on stormwater treatment "Regelblatt 35" rman guideline on rain analysis ATV 121 mmary s and Procedures drological background Rain measurement Return period Rain data format. Runoff generation | 18 iity approach |
| 3.2.2. 3.3. Ott 3.3.1. systems 3.3.2. 3.3.3. 3.3.4. 3.3.5. 3.4. Gu 3.4.1. and env 3.4.2. 3.4.3. 3.5. Ge 3.6. Su 4. Method 4.1. Hy 4.1.1. 4.1.2. 4.1.3. 4.1.4. 4.1.5. 4.2. Set | Requirement for combined sewer overflows for the emission approach Requirement for combined sewer overflows for the ambient water qual 21 her national guidelines on CSO design The approach for CSO design of the European Norm EN 752-4, "Drai outside buildings. Hydraulic design and environmental considerations" Legislation and Technical Guidance on CSO in Germany Legislation and Technical Guidance on CSO in Flanders (Belgium) Legislation and Technical Guidance on CSO in Flanders (Belgium) Legislation and Technical Guidance on CSO in Great Britain Legislation and Technical Guidance on CSO in Great Britain idelines on sewer design European guideline "Drain and sewer systems outside buildings. Hydr ironmental considerations", EN-752 Austrian guideline on sewer design "ÖWAV Regelblatt 11" Austrian guideline on stormwater treatment "Regelblatt 35" rman guideline on rain analysis ATV 121 mmary s and Procedures drological background Rain measurement Return period Rain data format. Runoff generation Surface routing. | 18 iity approach |

| 4.2.2 | 2. Pollution sources |
|---------|---|
| 4.2.3 | 3. Flow routing |
| 4.2.4 | 4. Quality models |
| 4.3. | Indicators related to the sewer system design |
| 4.3. | Introduction |
| 4.3.2 | 2. Sewer system performance indicators |
| 4.3.3 | 3. Receiving water impact indicators |
| 4.3.4 | 4. Rain characteristics indicators |
| 4.4. | Calculation of indicators |
| 4.4. | Programs used |
| 4.4.2 | 2. Hydrologic vs. hydrodynamic models |
| 4.4.3 | Basic catchment |
| 4.4.4 | 4. Pollutants in the wastewater streams |
| 4.4. | 5. Summary |
| 5. Perf | ormance assessment - Scientific background |
| 5.1. | Water Framework Directive and the urban drainage system, new indicators are needed |
| | 62 |
| 5.2. | Temporal variation of rain data and indicators for its analysis |
| 5.3. | Spatial variation of rain data and correlation between rain characteristics and sewer |
| system | performance indicators |
| 5.4. | Suitability of indicators for sewer system performance |
| 6. Con | clusions and Outlook |
| 6.1. | Water Framework Directive and the urban drainage system, new indicators are needed |
| | 72 |
| 6.2. | Temporal variation of rain data and indicators for its analysis |
| 6.3. | Spatial variation of rain data and correlation between rain characteristics and sewer |
| system | performance indicators |
| 6.4. | Suitability of indicators for sewer system performance |
| 6.5. | Outlook |

٩