

INDICATORS

In this case the infrastructure evaluated is only the sewerage system itself included exchange of energy with the surroundings and the export of sludge. Water supply is not included in the analysis. Table 1 shows the score of each of the chosen indicators in the two alternative sewerage systems. Included in the calculation is the construction and operation phase. The manufacturing of pipes, pumps and onsite treatment plants are not included

Table 1: Performance/score of the two sewerage systems

Indicators	Unit	Conventional alternative	Nature based alternative
Use of resources			
Electricity	kWh/p·y	207,2	154,39
Use of water	m ³ /p·y	65,70	53,29
Fossil energy	KWh/p	47,8	6,34
Energy recovery			
Energy (hot water or electricity) from biogas	kWh/p·y	92,5	0
Less use of manufactured fertilisers	kWh/p·y	2,99	3,8
Phosphorus to agriculture	g/p·y	454,3	573,7
Discharge of phosphorus to recipients	g/p·y	40	70
Chemicals for WWTP	kg/p·y	22,3	0
Discharge to earth			
Cd		0,038	0,013
Cu		7,44	2,48
Hg		0,022	0,0073
Pb		0,63	0,21
Discharge to air *			
SO ₂		0,024	0,0032
CO		0,052	0,0069
CO ₂		12,8	1,7
NO _x		0,22	0,03
Use of land	m ² /p	0,3	3,0
Influence on the neighbourhood			
Smell		very little	some
Noise		very little	some
Influence on the local habitat and landscape		some	some
Health and safety			
Risk of infections of water from sewage		very little	some
Influence on recreation		very little	some
Inconveniences with operation and maintenance on the sewerage systems		very little	estimated to be 20 times worse than conv.
Annual cost incl. capital, maintenance, etc	ecu/p a	906 ecu /p year	649 ecu /p year

(Diesel for haulage of sludge and chemicals, and subsequent pollution are not included at present)

EVALUATION

Weighting of the indicators of the two alternatives and calculation of "penalty points" of the two systems are shown in table 2. The penalty point is calculated by multiplying the weight with the relative score.

A panel consisting of a sanitary engineer, an agricultural expert, a landscape architect and a person living in the actual residential area have evaluated the weight of each indicator. The weighting principle is based on each panel person's apprehension of the distance to critical level and the relative importance of the problem represented by the indicator. The indicators not transferred from table 1 to table 2 are either judged to be rather equal for the two alternatives or of little importance. Some of the indicators in table 2 incorporate several indicators from table 1 when they are having the same type of effect. This is to make the weighting process less complicated. The results of the weighting are shown in table 2. As shown the performance of each alternative is expressed relatively so that the highest value of an indicator is given the relative value of 100 and the other alternative a value relatively to 100.

Discharge of CO₂ is given a relatively low weight because the relatively national contribution to global warming from the sewerage sector is very small (only 0,1 % according to Kärman 2000.) Use of chemicals in the WWTP is also given a small weight because mainly iron sulphate is used which is no threat to the Oslofjord.

The alternative with the lowest value for the penalty points is the most sustainable. Hence the conventional alternative has the best overall sustainability

Table 2: Weighting of the indicators of the two alternatives and calculation of "penalty points" of the two systems.

Indicator	Wght	Performance of the systems (inverse)		Penalty points	
		Conventional	Nature-based	Conventional	Nature-based
Net use of electricity	12	74	100	888	1200
Use of water	2	100	81	200	162
Fossil energy for construction (diesel) *	11	100	13	1100	143
Recirculated phosphorus	13	100	80	1300	1040
Discharge to water of phosphorus	11	57	100	627	1100
Chemicals for the W W T P	3	100	0	300	0
Discharge to the ground	8	100	33	800	264
Discharge to air. Local *	2	100	14	200	28
Discharge of CO ₂ . Global *	2	100	14	200	28
Use of area	12	10	100	120	1200
Influence on local area	6	95	100	570	600
Health and safety	8	90	100	720	800
Inconveniences with operation and maintenance on the sewerage systems	10	5	100	50	1000
SUM	100			7075	7565

(Diesel for haulage of sludge and chemicals, and subsequent pollution are not included at present)

It is very important to make sensitivity analyses on the weights to be able to find optimal and balanced distribution of the weights. One might find that only a small change in one of the weights may alter the conclusion, hence makes visible critical points to concentrate on in the weighting and score analysing process.

The trade off between cost and sustainability will normally be difficult but an important operation to make. This means that one will have to evaluate how much one will pay for sustainability. Looking at table 3 one sees that in this case one does have to make trade-offs between costs and sustainability because the conventional alternative is the most sustainable but the most costly.

Table 3. Comparison of costs and penalty points

Parameter	Conventional	Nature based
Annual cost incl. capital, maintenance, etc	906 ecu /p year	649 ecu/pyear
Penalty points	7075	7565

It is important to use the shown method with great care and not, for instance, draw the conclusion that the conventional alternative is ca. 7 % more sustainable than the nature based alternative because there is not any linearity between sustainability and the parameters in table 3.

If the water supply also had been included in the analyses together with the sewerage systems the analysis would have shown a more holistic picture, because water and sewerage are interconnected in many ways. Hence, setting the right borders for the systems analyses is very important.

TRANSFERABILITY

There is little transferability to other cases concerning whether conventional or nature-based systems are most sustainable because every situation and locality is unique and no generic conclusion can be found on what system is the most sustainable.

There is little transferability to other cases concerning the weights for local problem-indicators given in this example because these weights must reflect the local conditions. However one might consider the intentions behind the weights given to indicators reflecting global problems, when it comes to other sewerage systems.

The methods used in this case might be of interest to consider when performing sustainability analysis for other sewerage projects.

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