

IN - Identificati on Number	Author		Year	Main topic	Category	Title	Type of system	Type of water	Treatment level	Species of trees	Type of pollutant	Climatic conditions	Treatment performance	Biomass production	General comment	Database	Country
1	Conti, Toor (2018), Denmark	X	2018	biomass production	Case study - Experimental set up - pilot-scale systems	phytoremediation: growth, nitrogen and water use	Willow material (SRC) irrigated 2 years with untreated household wastewater used for a hydrothermal liquefaction process	municipal, domestic or household wastewater	household wastewater	willow (Salix schwerinii, Salix viminalis)	Total N &P	Denmark				Sciencedirect	Denmark
2	Bert Holm, Katrin Heinsoo	X	2013	Filtration efficiency - bioremediation of effluents	Case study - Experimental set up - pilot-scale systems	Municipal wastewater application to Short Rotation Coppice of willows – Treatment efficiency and clone response in Estonian case study	Experimental SRC, open field on former agricultural land with lysimeters (40 cm), no extra fertigation. Double row design, alternating inter-row distance of 1.5 and 0.75 m(space between cuttings 0.5m). 13 hectares(8 vegetation filter). 14800 and 17800 plants/ha, 160 mm water/from May-November	municipal, domestic or household wastewater	Municipal wastewater, mechanically pretreated (metal screen) + wastewater stabilisation ponds. Fertigation with 160mm	willow (Salix schwerinii, Salix viminalis)	Total N &P	cool-temperate, vegetation period 5-6 months, annual precipitation ca. 600 mm(growing season 350 mm).	58 % reduction in N, 70 % in P, fulfilled Estonian legislation	selection of more productive clones is important, more shoots and DW increased (compared to normal irrigation), large differences between clones (max. 41 t/ha). Up to 29.2 t/ha, medium 22t/ha yield	higher planting desnity or denser irrigation pipe network = no higher yield /should be avoided in order tzo save costs), wood yield increased by 40 % (control area).	Sciencedirect	Estonian
3	Truu, Heinsoo (2009) Estonia	X	2009	Impacts on soil microbiology under willow /secondary treated municipal wastewater	Case study - Experimental set up - pilot-scale systems	Changes in soil microbial community under willow coppice: The effect of irrigation with secondary-treated municipal wastewater		municipal, domestic or household wastewater	secondary-treated wastewater	willow		cool-temperate, vegetation period 5-6 months, annual precipitation ca. 600 mm(growing season 350 mm).	increased soil potassium concentration and soil biological activity (upper 10 cm soil layer). The irrigation water had a relatively low nitrogen and phosphorous content and water samples obtained from lysimeters indicated reduction of total nitrogen concentration by 55% and total phosphorous concentration by 74% in soil, respectively.	The average increases in soil microbial biomass and respiration activity were nearly similar in irrigated and control plots (0.40 and 0.36mgCg <sup>-1</sup> dw for biomass, 0.07mgCO2 g <sup>-1</sup> dwh <sup>-1</sup> for respiration). The average change of nitrogen mineralization activity was more than two times higher in non-irrigated plots (0.45 and 0.99 Ng <sup>-1</sup> dwd <sup>-1</sup> , respectively).		Sciencedirect	Estonia
4	Toome, Heinsoo (Estonia)	X	2009	willow leaf rust (plant diseases & design)	full-scale systems	The influence of canopy density on willow leaf rust (Melampsora epitea) severity in willow short rotation	Willow plantation	municipal, domestic or household wastewater	wastewater	5 willow species						Sciencedirect	Estonia
5	Postilla, Heiderscheidt (2020) Finland	X	2020	Energy yield (Input versus output) Biomass production, survival rates and nutrient uptake (2016-2018)	Case study - Experimental set up - pilot-scale systems	Function and biomass production of willow wetlands applied in the polishing phase of sewage treatment in cold climate conditions	0.035 ha wetland pilot (sealed bottom), cuttings with 30 cm spacing within rows and 70 cm between rows (density 47.000 plants /ha)	municipal, domestic or household wastewater	outflow of WWTP (polishing phase), increased amount of water from 5 mm/day to 23 mm/day	Willow cuttings (3 species, Gudrun, Karin, Klara)	Total N &P	Northern Finland, cool temperature, precipitation 280-320 mm	76-82% N and 86-63 P treatment efficiency. Nitrogen retention varied as summer average 66–86% while phosphorus 30–87%. The removal efficiency achieved for the K, Ca and Mg was 25%, -278% and -11%, in 2017 and 12%, -273% and -2% in 2018, respectively. In general, good removal of N and P was accomplished in the pilotscale willow wetland investigated in this study, as reported previously for this type of wetland (e.g. Dimitriou and Aronsson (2011))	GU 5.7t/ha & KA 1.7t/ha		Sciencedirect	Finland
6	Tzanakakis, Chatzakis, Angelakis (2012, Greece	X	2012	Filtration efficiency - bioremediation of effluents	Case study - Experimental set up - pilot-scale systems	Energetic environmental and economic assessment of three tree species and one herbaceous crop irrigated with primary treated sewage	one year old saplings, planted with 50 cm between plants and rows	municipal, domestic or household wastewater	treated wastewater from septic tank, primary	(Acacia cyanophyll a, Eucalyptus camaldulen		Iraklion, Greece, semi-arid with warm dry summers		Eucalyptus globules and E. camaldulensis produced 16 and 20 t ha-1 y-1 respectively 2 years. With regard to poplar, it has been reported 8 t ha-1 y-1 dry biomass.		Sciencedirect	Greece

7	Tzanakakis,	X	2011	Effects on soil, Filtration efficiency - bioremediation of effluents	Case study - Experimental set up - pilot-scale systems	Effluent application to the land: Changes in soil properties and treatment potential	experimental SRC, Crete, Greece. One year old eucalyptus & acacia & poplar. Each system 16 trees, two double rows, tensiometer at 30 & 60 cm	municipal, domestic or household wastewater	Municipal wastewater (BOD 348), effluent was applied to meet crop ET, daily rates of 30 kg BOD/ha/day, hydraulic load from 637-to 1074-to 1852 mm/year (3 years)	(Acacia cyanophylla, Eucalyptus camaldulensis, Populus nigra, and Arundo donax)	Total N & P	semi-arid (humid winters & dry warm summers. Precipitation ca. 450 mm	n.a.	n.a.	COD increased in top soil layer only, nitrate concentration increased over winter (leaching?). Increase of P content in soil, OM concentration constant in soil. Summary: increased soil fertility by SOM, N & P. Careful with NO3	Sciencedirect	Greece
8	Tzanakakis, 2015	X	2015	Biomass production, nutrient uptake	Case study - Experimental set up - pilot-scale systems	Prediction of Biomass Production and Nutrient Uptake in Land Application Using Partial Least Squares Regression Analysis		municipal, domestic or household wastewater	Municipal wastewater	(Acacia cyanophylla, Eucalyptus camaldulensis, Populus nigra, and Arundo donax)						Sciencedirect	Greece
9	Tzanakakis, 2003	X	2003	biomass production and filtration efficiency	Case study - Experimental set up - pilot-scale systems	Wastewater treatment and biomass production by slow rate systems using different plant species	Oct. 2000, 16 plants each species, 1 m between plants and rows	municipal, domestic or household wastewater	pretreated domestic wastewater (septic tank), hydraulic loading rate between 1100-1300 mm/year	eucalyptus (eucalyptus camaldulensis), acacia cyanophylla, and poplar (populus nigra), A. donax	standard	Iraklion, Greece, semi-arid with warm dry summers	reduction of 91 % COD (mainly within 15 cm of soil, smaller reduction until 60 cm), no large differences between species for treatment, organic load removed within 15 cm of soil. Removal rates between 70 to 94% of TKN in various SR systems have been reported. The removal efficiency of TP in this study appeared to be lower than the recorded in other systems in which it was exceeded 90%.	highest biomass production by acacia, than reeds, lowest by eucalyptus and poplar. Dry weight of produced biomass (ton/ha) Eucalyptus 4.51b, Poplars 6.00b, Acacia 13.91a, Reeds 8.13b.	advanced treatment systems of primary treated wastewater effluent – very high reductions of COD, TKN, TP, TC and FC of 95%, 94%, 85%, 99.9%, and 99.9%, respectively, were measured	MDPI	Greece
10	Forbes, 2017	X	2017	Filtration efficiency - bioremediation of effluents	Case study - Experimental set up - pilot-scale systems	SRC willow as a bioremediation medium for a dairy farm effluent with high pollution potential	5 ha SRC willow, 6 genotypes of energy crop willow	industrial wastewater	Dairy farm water (cattle faecal matter, urine and agri-nutrients), 0.3-0.9 gN, 0.5-90.3 mgP, 230-6600 BOD, hydraulic loading rate up to 4,4 mm/day	6 willow types	NPK,	Northern Ireland, 980 mm yearly rainfall	High treatment performance, no pollution to groundwater. Compared to the BOD concentrations (2603 ± 226 mg L <sup>-1</sup> ) of FDW this represented a difference of >99%. In leaf tissues the concentrations of nutrients N, P, K (average 34.06 g kg <sup>-1</sup> , 3.93 g kg <sup>-1</sup> and 18.57 g kg <sup>-1</sup> respectively) were much higher (by 80.9, 59.0 and 84.0% respectively).	higher biomass production, genotype major factor in crop yield and nutrient take-off. Biomass dry matter yields, harvested after a 3-year growth rotation, ranged from 26.7 to 42.9 Mg h <sup>-1</sup> 3yr <sup>-1</sup> . Wastewater irrigation is here estimated to increase the yields by 4–8 tDMha <sup>-1</sup> yr <sup>-1</sup> , or 30–100% compared to average yields for well-managed, rain-fed willow plantations on good soils	This magnitude of BOD reduction was also similar to the average (98%) reported from a study of constructed wetlands treating dairy farm soiled water effluents in Ireland.	Sciencedirect	Ireland
11	Curreen, Gill 2016, Ireland	X	2016	Filtration efficiency - bioremediation of effluents	full-scale systems	Willow-based evapotranspiration systems for on-site wastewater	6 full scale willow systems, Evapotrapiration system, with impermeable membrane,	municipal, domestic or household	secondary-treated wastewater	3 types of salix viminalis,	NPK, BOD	Ireland,	No zero discharge with Evapotranspiration	Growing depended on weed control, 2.4-6.9 dt/ha/yr (non effluent control site produced	zero discharge not possible due to rainfall (climate	Sciencedirect	Ireland



12	Curneen, Gill 2013, Ireland	X	2013	Filtration efficiency and evaporation rates	Case study - Experimental set up - pilot-scale systems	A comparison of the suitability of different willow varieties to treat on-site wastewater effluent in an Irish climate	Cylindrical containers (1000), one plant each	municipal, domestic or household wastewater	treated wastewater	salix viminalis, one plant per container	NPK	Ireland,	large % of NPK in the biomass (added nutrients stored in the biomass and the soil), most of the water ET. The retention of phosphorus was over 100% of total phosphorus added for all plants.The uptake of total nitrogen from these cultivars varied from 54% to 78% of the total nitrogen added. The retention of phosphorus was over 100% of total phosphorus added for all plants.	Cozzi, 2015 (Italy, Basilicata region). see fig 6.	This is lower than the results obtained by Dimitriou and Aronsson (2011) where approximately 95% of the total nitrogen applied was retained by the tree biomass.	Sciencedirect	Ireland
13	Dr. Paul Thomas Galbally, Alistair R Mcracken, Aaron Black	X	2014	Filtration efficiency - bioremediation of effluents	full-scale systems	Use of Short Rotation Coppice (SRC) willow for the bioremediation of effluents and leachates: Current Knowledge	12.9 ha SRC willow	industrial wastewater	partly treated wastewater from bakery and dairy industry	Willow			In terms of carbon footprint and climate change, the growing of 1 ha of willow for biomass would not only contribute to the local farming community but produce approximately 10 tonnes processed dry wood chip per year which would provide approximately 39,000 kWh energy – enough to supply the heat requirement for about 1 to 2 domestic houses. Over 15 years, this project is estimated to save NIW 50% in cost and 1500% in CO2 emissions.	The preferred planting machinery is a Swedish Step Planter which plants in double rows 0.75m apart with 1.5m between rows, 0.6m spacing between plants within each row (15,000 cuttings ha-1). Management of the crop post-planting up to cutback is crucially important as newly planted willow cannot effectively compete against most weeds.	ResearchGate	Ireland	
14	H. Rosenqvist, Dawson (2005) Northern Ireand	X	2005	Economic - avoided costs - value added	Economic evaluation - to calculate the	Economics of using wastewater irrigation of	Willow SRC in general	municipal, domestic or	wastewater	willow	NPK	Northern Ireland, 980 mm yearly			saved costs in the co.83 nventional	Sciencedirect	Ireland
15	Cozzi, 2015, Italy	X	2015	Economic - avoided costs - value added opportunity - profitable	Economic evaluation - to calculate the economics	A spatial analysis model to assess the feasibility of short rotation forestry fertigated with urban wastewater: Basilicata region case study	Spatial planing for one Italian region (check with UFZ, Indian region)	municipal, domestic or household wastewater	wastewater	willow, poplar					calculated number of WWTP which could be combined with a SRC	Sciencedirect	Italy
16	Guidi, 2007, Italy	X	2007	Filtration efficiency and evaporation rates	Case study - Experimental set up - pilot-scale systems	Evapotranspiration and crop coefficient of poplar and willow short-rotation coppice used as vegetation filter	SRC in lysimeters, planted with willow and poplar to measure Evapotranspiration. willow and poplar SRC used as vegetation filter and grown under fertilised (F) and unfertilised (NF) conditions, were determined for two successive growing seasons using volumetric lysimeters.	municipal, domestic or household wastewater	wastewater	willow and poplars			high water consumption of plants is related to the availability of nutrients	Thus aboveground dry biomass ranged from 6.6 (NF)–64 (F) t ha-1 in willow to 8.9 (NF)–44.4 (F) t ha-1 in poplar.		Sciencedirect	Italy
17	Stolarski, 2018, Poland		2018	willow biomass production but NO wastewater application	Case study - Experimental set up - pilot-scale systems	Willow productivity from small- and large-scale experimental plantations in		water	water	willow			The mean productivity on small-scale experimental fields (11.4 Mg ha-1 y-1 d.m.) was much			Sciencedirect	Poland
18	Ericsson, Rosenqvist, 2006, Poland		2006	Economic analysis of willow cultivation in Poland (No wastewater	Economic evaluation - to calculate the economics	An agro-economic analysis of willow cultivation in Poland		water	waste water and application	willow				We assume a 22-yr lifespan of the willow plantation		Sciencedirect	Poland
19	Kowalik, Randerson, 1993, Poland	X	1993	N & P removal, Filtration efficiency and evaporation rates	Case study - Experimental set up - pilot-scale systems	Nitrogen and phosphorus removal by willow stands irrigated with municipal waste water—A review of the Polish experience	0,5 ha willow SRC (4 willow species)irrigated with surface furrows (1,8 m apart), biomass production & quality of draining water was measured.	municipal, domestic or household wastewater	Municipal wastewater	Salix amygdalina, S. viminalis, S. americana, S.purpurea			88% removal of BOD, 41-43 for N &P	Annual yields for 2000 mm irrigation of two year rotation plants of Salix amygdalina (S. tiandra) was 14.4 t DM ha-1, S. viminalis 8.7 t DM ha-1, S. americana (S. con&a) 7.1 t DM ha-1, and S. purpurea (S. sabulosa) 5.0 t DM ha-1.	Max. irrigation load of 1000 mm (50 mm a week) instead of 2000 or 4000 mm	Sciencedirect	Poland

20	de Miguel, 2014, Spain	X	2014	Treatment and filtration efficiency and evaporation rates	<b>Case study - Experimental set up - pilot-scale systems</b>	Treating municipal wastewater through a vegetation filter with a short-rotation poplar species	poplar SRC, 10000/ha, 10 each row,	municipal, domestic or household wastewater	Municipal wastewater, 0,5 m3/day	poplar	BOD5, TKN, TP, N:P:K	Spain, Seville,	DOC & COD removal of 85 %, increase in soil organic matter (from 1-2.8%), P 85 %, N 73%		even with leaching, groundwater was not affected, additional nitrification steps may have taken place	Sciencedirect	Spain
21	Alarcon, 2018, Spain	X	2018	Impacts on microbiology and filtration efficiency	<b>Case study - Experimental set up - pilot-scale systems</b>	Effects of treated wastewater irrigation on lemon trees	12 ha with lemon trees, 10 ha with lemon trees	municipal, domestic or household wastewater	secondary wastewater & tertiary treatment, high concent. Of boxes	Lemon trees		Murcia, Spain 20300 mm rainfall	no results published, no negative effects on lemon trees & soil			ResearchGate	Spain
22	Martinez-Hernandez, 2017, Spain	X	2017	Filtration efficiency of poplars, emerging organic contaminants-bioremediation of effluents	<b>Case study - Experimental set up - pilot-scale systems</b>	Removal of emerging organic contaminants in a poplar vegetation filter	poplar SRC system	municipal, domestic or household wastewater	pre-treated wastewater	poplar	antibiotic, anti-inflammatory etc.	Spain, Seville,	more than 90 % of selected EOCs were removed (except ketoprofen), concentration found in the first 90 cm of soil,			Sciencedirect	Spain
23	Oliveira, 2020, Spain		2020	biomass production based on poplar, SRC, NO wastewater	<b>full-scale systems</b>	Poplar Short Rotation Coppice Plantations under Mediterranean Conditions: Wastewater and sewage		water		poplar					in different European countries, ranging	MDPI	Spain
24	I. Dimitriou*, P. Aronsson	X		Filtration efficiency - bioremediation of effluents	<b>Case study - Experimental set up - pilot-scale systems</b>	sludge application to willows and poplars grown in lysimeters—Plant response	lysimeter (16) pilot plant	municipal, domestic or household wastewater	Untreated municipal wastewater, 7 mm/d only	willow and poplars		Uppsala, Sweden mean annual temperature is 5.5 °C and 527	90-96 % and 94% removal rate for N and P			Sciencedirect	Sweden
25	Börjesson, Berndes, 2006, Sweden	X	2006	Vegetation filters, Economic - avoided costs - value added opportunity - profitable	<b>Case study - Experimental set up - pilot-scale systems</b>	The prospects for willow plantations for wastewater treatment in Sweden	Example	municipal, domestic or household wastewater	wastewater	willow			An annual municipal wastewater load of 600 mm, containing about 100 kg N, 20 kg P and 65 kg K, will supply not only the required water, but also the requirements of N and other macronutrients. The root systems will then take up 75–95% of the nitrogen and phosphorus in the wastewater. N retention increases with increasing buffer width up to a width of about 25 m, where often more than 70% of the total N content is removed from the water flow. The overall net energy yield in conventional willow production in Sweden is, on average, about 170 GJ ha <sup>-1</sup> yr <sup>-1</sup> . Thus,	Wastewater irrigation is here estimated to increase the yields by 4–8 tDMha <sup>-1</sup> yr <sup>-1</sup> , or 30–100% compared to average yields for well-managed, rain-fed willow plantations on good soils (Table 1).	average nutrient content in Swedish wastewater corresponds nutrient requirements of willow SRC. The purification efficiency of willow vegetation filters has been demonstrated in several countries, e.g. Sweden, Poland, Denmark and Estonia. N retention increases with increasing buffer width up to a width of about 25 m, where often more than 70% of the total N content is removed from the water flow.	Sciencedirect	Sweden
26	Dimitriou, Rosenqvist, 2010, Sweden	X	2010	biomass production, biological and economic potential	<b>Economic evaluation - to calculate the economics</b>	Sewage sludge and wastewater fertilisation of Short Rotation Coppice		municipal, domestic or household	wastewater	willow and poplars				Growth increase reported in many cases	At current woodchip prices in Sweden, the gross	Sciencedirect	Sweden
27	Aronsson, Dahlin, Dimitriou, 2009, Sweden		2009	Filtration efficiency - bioremediation of landfill leachate	<b>Case study - Experimental set up - pilot-scale systems</b>	Treatment of landfill leachate by irrigation of willow coppice – Plant response and treatment efficiency	16 400m2 plots on arable land , 2 types of salix in a double-row system, with chemical weed control, groundwater control wells	landfill leachate	pretreated Landfill leachate (three different rates of leachate) one control	willow (Tora & Gudrun)			N retention low (30-50%) first years but higher in second year (78-85%), P no retention in the first year, 77-87% second year, TOC retention 61-72%,	high survival rate and good biomass growth, no negative effects on plants even with extreme high N loads	Water balance calculated with Persson 1994)	Sciencedirect	Sweden
28	Dimitriou, Aronsson, 2003, Sweden	X	2003	Filtration efficiency -N leaching bioremediation	<b>Case study - Experimental set up -</b>	Nitrogen leaching from short-rotation willow coppice after	1200 1 lysimeters, with sand and clay, wastewater with 400mgN	municipal, domestic or landfill	wastewater	Willow		Sweden, Enköping	plants in clay lysimeters higher than sand, twice as much	plants in clay lysimeters higher than sand, twice as much		Sciencedirect	Sweden
29	Rosenqvist, Ness, 2004, Sweden		2004	Economic - avoided costs - value added	<b>Economic evaluation - to calculate the</b>	An economic analysis of leachate purification through		landfill leachate	landfill leachate	Willow			wastewater application 130kg			Sciencedirect	Sweden
30	Aronsson, Perttu 2001	X	2001	Filtration efficiency - economic	<b>General overview</b>	Willow vegetation filters for wastewater treatment and soil	general view	municipal, domestic or	Municipal wastewater	Willow						The Forestry Chronicle	Sweden
31	Aronsson, Heinsoo, Perttu 2002	X	2002	Filtration efficiency - bioremediation of effluents	<b>Case study - Experimental set up - pilot-scale systems</b>	Spatial variation in above-ground growth in unevenly wastewater-irrigated willow Salix viminalis plantations		municipal, domestic or household wastewater	treated wastewater	willow					wastewater could be distributed even and equally in the SRC	Sciencedirect	Sweden

32	Börjesson, 1999, Sweden	X	1999	biomass production, environmental benefits	<b>General aspects</b>	Environmental effects of energy crop cultivation in Sweden—I: Identification and quantification		municipal, domestic or household wastewater	wastewater	willow				perennial energy crops instead of annual crops reduces leaching. Around 75±95% of the nitrogen and phosphorus in the waste water could be removed in energy crop cultivations, when the waste water load is 500±1000 mm /ha yr [70±72]. An increase in waste water load to 2000±5000 mm/ha yr, will decrease the treatment efficiency to 10±55% [69, 73]. It has been estimated that a waste water load of about 600 mm/ha yr, containing 125 kg nitrogen, will not	Sciencedirect	Sweden
33	Elowson, 1999, Sweden,	X	1999	biomass production, buffer filter,	<b>Case study - Experimental set up - pilot-scale systems</b>	Willow as a vegetation filter for cleaning of polluted drainage water from		municipal, domestic or household	run-off from agricultural land	willow, Salix viminalis.					Sciencedirect	Sweden
34	Hasselgreen, 1998, Sweden	X	1998	biomass production, review for Sweden	<b>full-scale systems</b>	Use of municipal waste products in energy forestry: highlights from 15 years of experience	Salix systems in Sweden	municipal, domestic or household wastewater	Pre-treated wastewater	willow	NPK	20 mm/day during vegetation period (optimum 6mm/day), 166kg N; 22kgP & 174kgK per hectare from May-October. NPK ratio of 100:14:105) ideal for salix (100:13:65). The removal rates calculated on a mass balance basis within the lysimeter study amounted to 85±95%, 95±96% and 91±98% for N, P and BOD, respectively.	three times higher compared with tap water and no fertilizers		Sciencedirect	Sweden
35	Kurth Perttu, 1999, Sweden	X	1999	Filtration efficiency - economic	<b>full-scale systems</b>	Environmental and hygienic aspects of willow coppice in Sweden	General approach	municipal, domestic or household wastewater	Municipal wastewaters	willow		willow cultivations have a pronounced capacity to take up nutrients and heavy metals (including cadmium). use of wastewater gives an almost perfect composition of nutrients and, at the same time, necessary amounts of water.	willow cultivations enhance biodiversity compared with conventional agricultural crops and monospecific conifer plantations. The positive effect of willow coppice instead is mainly secondary, which means that this type of biomass can replace a corresponding part of fossil fuels (oil, coal and gas) which, compared with biofuel, are more polluting to the environment. There is an Ideal proportions by weight between the most important mineral nutrients for maximum willow production	The purification efficiency of willow vegetation filters has been demonstrated in several countries, e.g. Sweden, Poland, Denmark, and Estonia. The vegetation filter procedure makes use of most of all the nutrients, especially since the composition of municipal wastewater is almost perfect for the willow crop.	Sciencedirect	Sweden



36	Lea Rastas Amofah, Jonathan Mattsson, Annelie Hedström, 2012	X	2012	biomass production	full-scale systems	Willow bed fertigated with domestic wastewater to recover nutrients in subarctic climates	A full-scale compact willow bed was intensively fertigated with domestic wastewater in a cold climate to examine biomass production, the recovery of nutrients in willow biomass, and wastewater treatment. The performance of the willow bed was assessed for two years, covering three growing seasons. The total area covered by the willow bed, including the dispersion zone, was 32 m2.	municipal, domestic or household wastewater	wastewater	willow		Highest rainfall occurred between June and August (60-80 mm) and the maximum temperature was 15 ° C.	The willow bed was shown to be an efficient prefilter for reducing the abundance of particulate and organic matter, leaving the bulk of the remaining nutrients in forms that could be recovered in subsequent treatment steps. more than 90% of the TSS was removed from the influent. The willow bed efficiently reduced both BOD7 and COD, by >85% and ~80% respectively. the tot-N concentrations was typically reduced	The studied frost-tolerant willow clones produced good biomass yields per unit area (6–7 ton dry matter/ha and year) under intensive fertigation with dense planting and continuous harvesting. The estimated nitrogen accumulation in above-ground biomass was 210 kg/ha and that of phosphorus was 30 kg/ha. The overall biomass production over the three growing seasons was estimated to 21 ton DM/ha for <i>S. × viminalis</i> (Karin) and 19 ton DM/ha for <i>S. dasyclados</i> (Gudrun). The increased biomass production in Year 2 was associated with substantial increases in the uptake of N and P after the first growing season, for both clones. The studied willow bed produced high quantity of biomass per unit area.	Overall, our results indicate that frost-tolerant willow clones fertigated with wastewater may be an attractive option as a component of a nutrient-retaining wastewater treatment system for cold climates. However, it is necessary to further assess the impact of potential long-term variations in hydraulic load and ambient temperature on the biomass yield of willow grown in cold climates.	Sciencedirect	Sweden
37	Jaconette Mirck, J.G.Isebrands, Theo Verwijst, Stig Ledin, 2004, Sweden	X	2004	terminology and definitions of phytoremediation, 5 cases	terminology and definitions	Development of short-rotation willow coppice systems for environmental purposes in Sweden	Applications of phytoremediation in Sweden; 5 examples Månstorp: The cuttings were planted in a double row system, with a stool density of about 20,000/ha. Enköping: All fields have a double-row system with a density of about 13,000 stools per hectare. Höbytorp: The total area of SRWC is about 11.5 ha and cultivated with the willow clone Tora. Heby: The nearby willow vegetation filter has a surface area of about 2 ha. Stool density in the field is about 14,000 stools/ha. Aitik: Many local herbaceous and woody plant species have been tested, including different species of willow well adapted to the climate and site.	municipal, domestic or household wastewater	aricultural , domestic and treated wastewater	willow		threshold value of 5 ° C	Månstorp: Biomass production results and nutrient analyses indicated that more than 60% of the nitrogen was incorporated in the biomass while nitrogen also was lost from the system by denitrification. Preliminary studies of this system indicate that the willow clones used here are relatively tolerant to the applied chlorine levels.	Aitik: The growing season (threshold value of 5 °C) is normally only 120 days, and therefore less suitable for biomass production.		Sciencedirect	Sweden
38	K.L.Perttu, P.J.Kowalik. 1997, Sweden & Poland	X	1997	Filtration efficiency - economic	full-scale systems	Salix vegetation filters for purification of waters and soils.	The area was divided into four plots (each 20 x 15m2 in size), two for wastewater irrigation and two for control. 1992-1994. wastewater has a proportions of nitrogen, phosphorus, potassium, calcium, magnesium and sulphur.	municipal, domestic or household wastewater	Municipal wastewaters	willow Salix spp	Cd	Precipitation was between 142-219 mm. The air temperature was 16 °C approx and potential ET was 430 mm.	The analysis showed that about 20 g Cd can be removed by 10-12 tDM stem wood harvest per hectare per year. In this case the effect of wastewater gave an increase in the yield by 164-185%. Mean efficiency 94% BOD5, 42% TN and 46% P2O5. The corresponding efficiency during the three years of N removal was 41.3%, P 42.9%, and K 2.3%.	The biomass yield during the two years was 2-3 times higher in the fertilised plots compared to the unfertilised plots. the concentration of Zn in plant tissues can be as hig as 5% on a dry matter basis. The experiences and results indicate that the willow vegetaion filter approach to purification of municipal wastewaters and sewage sludges, as well as of heavy metal contaminated soils, may be a practicable and economically freasible way to manage and utilize the residual products. 18 tDM ha-1-3yr.	Swedish and Polish experiences of vegetation filter efficiencies have been demonstrated in several laboratory, field lysimeter and full-scale experiments.	Sciencedirect	Sweden and Polish

39	A. Sugiura, S.F. Tyrrel, I. Seymour and P.J. Burgess, 2008, UK	X	2008	Filtration efficiency - bioremediation of effluents	<b>Case study - Experimental set up - pilot-scale systems</b>	Water Renew systems: wastewater polishing using renewable energy crops	24 plots of 12.25 m <sup>2</sup> (3.5 m by 3.5 m spaced with a 1 m pathway). 16 trees in each cover. Willow and eucalyptus received more than 900 mm of effluent corresponding to more than 290 kgN/ha, 17 kgP/ha and 220 kgK/ha. And poplar and unplanted plots received less than 190 kgH/ha, 17 kgP/ha and 120 kgK/ha. Soil samples were collected at 6 depths over the field. 16 drippers (4L/hour) per plot.	municipal, domestic or household wastewater	secondary treated effluent (municipal wastewater)	Willow, poplar and eucalyptus	NH <sub>4</sub> , PO <sub>4</sub> , TP, TON, TN, K.	The mean annual precipitation is 629 mm, 10°C mean annual temperature and an annual average Penman evapotranspiration of 1,4 mm/day.	Average wastewater N, P, K composition is comparable to optimum compositions for SRC. NH <sub>4</sub> REPRESENTS 1.3% of N in the effluent. Ammonia was not detected in soil water samples at 30 and 60 cm. To conclude on TN and K concentration, irrigation is starting to have an effect on soil saer chemistry but it is still limited. Leaf nitrogen concentration was 94% higher in bothWWD1 andWWD2 treated trees than in UI and PWirrigated	Groundwater chemistry was unaffected by irrigation. Willows and eucalyptus can absorb almost a third more effluent than poplar and unplanted plots without having any significant effect on soil water chemistry. Tree irrigated with wastewater grew faster than nonirrigated trees. where the poplar responding most quickly and willow least quickly.	SRC is not new, related research has been conducted in Sweden, the USA, Australia and New Zealand. Systems can retain efficiently N,P and K from wastewater when effluent is applied to maintain soil moisture at field capacity. No effects on groundwater chemistry.	IWA publishing	UK
40	A.Jerbi, N.J.B.Breron, E.Sas, S.Amiot, X.Lachapelle-T., Y.Comeau, F.E.Pitre, M.Labrecque. 2020, Canada	X	2020	biomass production	<b>full-scale systems</b>	High biomass yield increases in a primary effluent wastewater phytofiltration are associated to altered leaf morphology and stomatal size in Salix miyabeana	The Salix miyabeana 'SX67' plantation was established at a density of 16,000 trees ha <sup>-1</sup> across four hectares northeast of Montreal, Canada. Twelve experimental square plots of 100 m <sup>2</sup> (10 m × 10 m), each containing six rows of trees, were treated with one of four treatments (three plots per treatment): unirrigated control (UI), potable water (PW), primary effluent wastewater dose one (WWD1) and primary effluent wastewater dose two (WWD2) irrigated.	municipal, domestic or household wastewater	pre-treated effluent (municipal wastewater)	Salix miyabeana is a species of willow native to northern Japan	COD, N, NH <sub>4</sub> , Nox, P	The average annual precipitation was 1102 mm for 2005–2015.	total nitrogen concentration in the soil pore water was reduced to 5–13% of that in wastewater. Leaf nitrogen concentration was 94% higher in bothWWD1 andWWD2 treated trees than in UI and PWirrigated trees.	<b>Biomass yield increases by 56-207 %.</b> The total harvested biomass yields were higher for both doses of wastewater irrigated trees compared to UI and PW irrigated trees after two years of growth. Wastewater irrigation increased dry matter biomass yields from 18.3 ± 3.5 t ha <sup>-1</sup> yr <sup>-1</sup> and 13.1 ± 1.6 t ha <sup>-1</sup> yr <sup>-1</sup> in unirrigated and PW irrigated trees to 28.8 ± 6.3 t ha <sup>-1</sup> yr <sup>-1</sup> and 40.4 ± 4.9 t ha <sup>-1</sup> yr <sup>-1</sup> in WWD1 and WWD2, respectively	Collectively, this study suggests phytofiltration plantations could treat primary effluent municipal wastewater at volumes of at least 19 million litres per hectare and benefit from increased yields of sustainable biomass over a two-year coppice cycle.	Sciencedirect	Canada
41	Xavier Lachapelle-T., Michel Labrecque, Yves Comeau, 2019	X	2019	Filtration efficiency - bioremediation of effluents	<b>Case study - Experimental set up - pilot-scale systems</b>	Treatment and valorization of a primary municipal wastewater by a short rotation willow coppice vegetation filter	The experimental design included nine plots that were irrigated with groundwater (L0=14 mm/d) or two primary effluents (L1=10 and L2=16 mm/d) for 111 days. The experiment took place on a two-hectare willow plantation. Salix miyabeana 'SX67' was planted at a density of 16,000 plants/ha (1.83 m row spacing, 0.34 m plants spacing on row). An experimental block design comprising three treatments, one groundwater loading rate (L0) and two primary effluent loading rates (L1 and L2) replicated three times for a total of nine 108 m <sup>2</sup> (10.8 × 10 m) experimental plots was set up. The primary municipal effluent irrigated had an average concentration of 224 mg COD/L, 122 mg BOD5/L, 31 mg N/L, 3.1 mg TP/L and 1.5 mg o-PO4/L and a pH of 7.7.	municipal, domestic or household wastewater	primary treated wastewater	willow	BOD5, TKN, TP, N:P:K	The region has a humid continental climate with a high temperature amplitude.. Average temperatures measured during the willow growing season (May 1st to October 31st; 16.5 °C) and the experimental irrigation period (July 20th to November 8th; 15.3 °C) were slightly higher than the 2006–2015 normal (15.9 °C and 14.2 °C, respectively; Fig. 1). Total rainfall during the growing season	This research showed that SRWCs operated on coarse-textured soils allow efficient removal of organic matter (91% of COD for L1 and L2) and nitrogen (98% of TKN for L1 and L2) from wastewater. Similar average COD load removal efficiency of 91 ± 6% and 91 ± 4% were achieved for L1 and L2 loadings. average TKN load removal efficiency of 98 ± 1% and 98 ± 6%. Average TN load removal efficiency of 94 ± 11% and 87 ± 17%. Average TP load removal	Average annual biomass yields of 12 ± 4, 22 ± 8 and 26 ± 7 t DM ha <sup>-1</sup> yr <sup>-1</sup> Nitrogen woody biomass uptake ranging from 88 to 220 kg N/ha and 104 to 260 kg N/ha. These uptake account for 24%–59% and 18–45% of nitrogen applied during the experiment. Uptake in root and leaf biomass plus denitrification of 128–260 kg N/ha and 247–403 kg N/ha, which account for 35%–70% and 43%–69% of nitrogen applied. Phosphorus woody biomass uptake ranging from 9 to 26 kg P/ha =24%–59% applied.		Sciencedirect	Canada



42	WertherGuidi Nissim, AhmedJerbi, BenoitLafleur, RémyFluet, MichellLabrecque. Canada, 2015	X	2015	Filtration efficiency - bioremediation of effluents	<b>Case study - Experimental set up - pilot-scale systems</b>	Willows for the treatment of municipal wastewater: Performance under different irrigation rates	The experimental site was then planted at density of about 16,000 plants per hectare with the willow cultivar Salix miyabeana SX67. Four treatments corresponding to four wastewater doses were scheduled, and each treatment was applied along ten willow rows. With an increase of wastewater supply between treatments of about 33% in the first year and 50% in the second year. In addition to the wastewater treatment, a fertilization treatment.	municipal, domestic or household wastewater	Municipal wastewater	willow	N, P, K, Ca and Mg	The region has a humid continental climate characterized by wide seasonal temperature variations, warm, humid summers and cold winters. The average annual temperature for the 1981–2010 period was 6.4 °C, and average annual precipitation was 998 mm, with 40% falling during the growing season.	willows were able to remove nearly 90% of the N and 85% of the P found in the wastewater.	Fertilization also had a positive effect on biomass yield but only during the first rotation, after which both treatments were not significantly different. This would support the claim that willows are not only well adapted to withstand prolonged flooded or saturated soils but that some are also characterized by high water requirements. Finally, we also noticed a significant increase of biomass yield following wastewater supply. Finally, we also noticed a significant increase of biomass yield following wastewater supply. In this case, the abovementioned Swedish study reported average biomass yield of 10 Mg ha <sup>-1</sup> yr <sup>-1</sup> . The average biomass production achieved in our study over two rotation cycles was 14 Mg ha <sup>-1</sup> yr <sup>-1</sup> to 20 Mg ha <sup>-1</sup> yr <sup>-1</sup> .	Eastern Canada is one of the regions in the world where willow crop shows very high levels of biomass yields both in the short- and the long-term periods. researchers in Sweden have reported removal rates up to 90–96% for N and 94% for P in short-rotation coppice willow irrigated with untreated wastewater containing high loads of nutrients.	Sciencedirect	Canada
43	SimonAmiot, AhmedJerbi, XavierLachapelle-T. ChloéFrédette, MichellLabrecque, YvesComeau. Canada, 2020	X	2020	Filtration efficiency - bioremediation of effluents	<b>full-scale systems</b>	Optimization of the wastewater treatment capacity of a short rotation willow coppice vegetation filter	The SRWC vegetation filter was installed in a two-hectare willow plantation (Salix miyabeana 'SX67' at 16000 plants/ha) established in 2008 and harvested in 2011 and 2015 (two-year-old stems on ten-year-old plants in the fall of 2017).	municipal, domestic or household wastewater	Municipal wastewater	willow	TKN, TN, COD	The climate of the region is humid continental with marked seasonal temperature variations. On site measurements were recorded during the study, between May 1 and October 31, 2017. The on-site weather station measured average minimum and maximum temperatures during this period of 9.8 ± 5.6 °C and 22.1 ± 6.5 °C, respectively. The local WRRF measured total rainfall during	total Kjeldahl nitrogen (TKN) loading removal decreased slightly at the beginning of November from 98 to 91% but remained constant over the course of the growing season. TN removal remained near 90% until the end of September and then decreased to 45% by November 9. The TP removal was 98%. COD annual loading removal of 96% for both treatments.	Willow biomass yield (which is related to ET) varies depending on the number of years of plant growth and coppicing.	The proposal is a new method to calculate the evapotranspiration rate from plant physiological data, introducing an $\alpha$ factor based on direct transpiration measurements. Nonetheless, while the irrigation was at its peak in July, the loading removal was still greater than 90%. The drop of loading removal was approximately similar between TKN and TN for L1.	Sciencedirect	Canada
44	R.D. Hangs, J.J. Schoenau, K.C.J. Van Rees, and H. Steppuhn. 2011	X	2011	Filtration efficiency - bioremediation of effluents	<b>Case study - Experimental set up - pilot-scale systems</b>	Examining the salt tolerance of willow (Salix spp.) bioenergy species for use on salt-affected agricultural lands	A total of 592 pots were used (37 willow varieties four saline soils four replicates).	industrial wastewater	Industrial water	willow	Na, Ca, and Mg sulphate salts		Most of the willow varieties tested in this study were able to tolerate moderately saline soils (ECe55 dS m <sup>-1</sup> ).	Furthermore, several varieties (Alpha, India, Owasco, Tully Champion, and 01X-268-015) showed no reduction in growth with a severe salinity level (ECe58 dS m <sup>-1</sup> ).	Establishing purpose-grown willow plantations with salt-tolerant varieties on salt-affected soil provides utility for otherwise non-productive land, thereby avoiding the displacement of arable land from food production.	Canadian Science Publishing	Canada



45	Paul Galbally, Declan Ryan, Colette C. Fagan, John Finnan, Jim Grant, Kevin McDonnell, Ireland, 2012	X	2012	Filtration efficiency	<b>Case study - Experimental set up - pilot-scale systems</b>	Biosolid and distillery effluent amendments to Irish short rotation coppiced willow plantations: Impacts on groundwater quality and soil	Organic byproduct, namely biosolid (BS) and distillery effluent (DE), was spread on six plots (each with a plot area of 0.059 ha) at OB treatment rates of 100%, 50% and 0%. The study was conducted over two years. The 350 ha facility. The plantation area was 0.72 ha.	industrial wastewater	Industrial water - distillery effluent	willow	NO3, Cu, Cd, Cr, Pb, Ni, and Zn	Annual temperature 4,6-9,7°C) Annual rainfall 822,9 - 937,6mm Rainfall 50,5-109,3 mm	There was no evidence of NO3 percolation to groundwater GW. For GW P there was evidence of leaching in plots spread with BS, but not in plots spread with DE. The average concentration of GW K was high for all plots, average GW Cu did not breach GTV (groundwater threshold values) for any plots, in terms of other Heavy Metals, there were individual (monthly) breaches of GTV observed for Cd, Cr, and Pb. Risk of pollution following BS and		In terms of short-term assessment, risks to GW quality and soil-quality from DE and BS amendment to energy crops appear limited.		Ireland
46	Michael Carlson, Canada, 1992	X	1992	Filtration efficiency - economic	<b>full-scale systems</b>	Municipal effluent irrigation of fast-growing hybrid poplar plantations near Vernon, British Columbia	With a population of 23,000, Vernon creates approximately 4 million cubic meters of wastewater per year. In 1990, there were almost 6000 trees/ha. Vernon's treated effluent averaged 21 ppm N, 8 ppm P and 16 ppm K. At these concentrations and irrigation rates the plantation received 158 kg N, 60 kg P and 120 kg K per hectare during the fifth growing season.	municipal, domestic or household wastewater	Municipal wastewater	Poplar (P. trichocarpa x P. deltoides)	N, P, K	Annual precipitation averages 35-41 cm/yr and is fairly evenly distributed throughout the year. Daily temperature averages in July and January are 20°C and -5 °C respectively. Summers are warm with cool nights and winters are mild with subfreezing periods.	In the third year, the concentration of N, P and K in the foliage increased. Nutrient uptake rates by the woody biomass were N 71-42%, P 29-20%, K 50-33%, Ca 21-14%, Mg 8-5%, Na 0.6-0.5%, Mn 46-36%, Zn 78-70%, Cu 18-4%, Fe 30-22%. efficiency of the soil-plant system in removing nutrients added through wastewater was N 97-95%, P 97-94%.	Woody biomass production of the plantation between 11-24 Mg/ha. Total wood biomass was almost 8000 g/tree and 2000 g/tree of tree leaf biomass.	While these nutrient quantities seem high citations in the literature suggest a fully stocked 4-5 year old hybrid poplar stand may require more than 200 kg N per hectare for maximum production.	The Forestry Chronicle	Canada
47	Hector G. Adegbidi, Timothy A. Volk, Edwin H. White, Lawrence P. Abrahamson, Russell D. Briggs, Donald H. Bickelhaupt. USA, 2001	X	2001	biomass production	<b>Case study - Experimental set up - pilot-scale systems</b>	Biomass and nutrient removal by willow clones in experimental bioenergy plantations in New York State	Clone SV1 (Salix dasyclados), an irrigated and fertilized planting with a density of 36,960 trees/ha harvested on a 3-year rotation. This study was conducted in 3 different experiments, all of which were established with long dormant hardwood cuttings. Experiment #1, planted in 1987, was a 2x6 split-plot factorial design with 3 replicates of each treatment. 2 levels: fertilized and non-fertilized (N, P, and K as ammonium nitrate, treble superphosphate and muriate of potash). The trial was hand-planted at spacing (107,600 plants/ha). Exp. #2 was a 2x3x3 completely randomized split-plot factorial design. Two willow clones (SA22 and SV1) were hand-planted 159,560 plants. With an annual fertilization rates. Exp. #3 was a 2x2 split-plot factorial design. Irrigation was the whole-plot factor with two levels (irrigated and non-irrigated).	municipal, domestic or household wastewater	treated wastewater	willow and poplars	N, P, K, Ca and Mg	Developed in a gravelly sandy outwash parent material, it has a loam texture with a gravel content varying from 25% in the Ap horizon to 60% in the IIC horizon.	Annual biomass production of 15-22 dry Mg/ha removed 75-86, 10-11, 27-32, 52-79 and 4-5 kg/ha/year of N, P, K, Ca and Mg, respectively. Within treatment, the ranking of element removal was consistent: N>Ca>K>P>Mg. Annual removal ranges were 18-103 kg/ha for N, 1.7-12.6 kg/ha for P, 7-44 kg/ha for K, 17-103 kg/ha Ca and 1.8-6.2 kg/ha for Mg. Fertilization significantly increased removals of N, P and K but not Ca and Mg. The observed	Fertilization and irrigation increased rates of nutrient removal by means of increased biomass production. Wood biomass was harvested annually, after leaf fall. The average annual biomass production ranged from 2.5 Mg/ha to 27.5 t/ha. Clone SA22 had the lowest biomass production while clone SV1 had the highest biomass production. Whether fertilized or not, willow clone SAM3 had the lowest removal of N, P, K and Ca; willow clone SH3 had the highest removals of Ca; and non-fertilized hybrid poplar clone NM5 had the highest removals of P and K. As expected, whole-tree harvesting in natural forest stands removed fewer nutrients on average compared to SRIC.	Biomass production, nutrient removal and nutrient use efficiency in willow bioenergy plantations is strongly affected by the selection of clonal material. This study also showed that, due to their relatively high nutrient requirement, willow biomass crops have potential for successful use in systems design to manage nutrient runoff from agriculture fields and wastewater.	Sciencedirect	USA

48	William E. Sopper, 1972 outdated	X	1972	Filtration efficiency - bioremediation of effluents	Case study - Experimental set up - pilot-scale systems	Disposal of municipal waste water through forest irrigation	The red pine plantation was established on an abandoned agricultural field in 1939. Trees were plantaed at a spacing of 2.4x2.4 m. Average tree diameter in 1963 was 17.3 cm and average height was 10.7 m. The forest floor was completely covered with a 5 cm layer of pine needles which was part of a mor humus. The rate of application was 3.64 cm/hr with various plots receining weekly amounts of 2.5, 5 or 10 cm during the period from 28 to 33 weeks.	municipal, domestic or household wastewater	Municipal wastewater	Red pine	N, Organic-N3, P, K, Calcium, Magnesium , Sodium, Chloride, Boron and Manganese	The soil is Hublersburgh-Hagerstown complex whit a surface texture ranging from silt loam to silty clay loam with slopes ranging from 3 to 20%. During the past nine years, there has been a total deficit of 178 cm of precipitation which is almost equivalent to 2 years of normal precipitation.	The concentration of nitrate-nitrogen which was reduced by 68 to 81% a the 30 cm soil depth during the first year (1963) gradually diminished during the 6 years until renovation at the 120 cm soil depth only ranged from 27 to 70%. P>90%. Phosphorus concentrations at the 60 cm soil depth were reduced by 98 to 99%. All pollutants have a removal percentage greater than 50%. MBAS was reduced by approx. 70% with percolation is 78-	Results indicated that weekly irrigation of red pine with 2,5 or 5 cm of sewage effluent did not significantly increase diameter growth. Average annual diameter growth of the mixed hardwood species was not affected by the 2,5 cm/week application but was significantly increased on the plots which received 5 and 10 cm/week. During the 6-year period 1963 to 1968, average dry matter production was 6196 kg/ha on the irrigated plot and 1848 kg/ha on the control plot. This represents an average annual increase of 235%. Annual increases ranged from approximately 100 to 350%. Average height of the predominant plant species was 134 cm on the irrigated plot in comparison to 40 cm on the control plot.	TREE SEEDLING SURVIVAL AN DGROWTH The second disposal site consistes of about 8 ha of mixed oak and, although some parts are irrigated during the summer, it is used primarily for winter irrigation. Winter application rate is 0.64 cm/hr with a weekly amount of 5 cm. Each block contained 10 trees of each species or a total of 80 trees per block. First year survival on the irrigated plot was 88% and on the control plot, 52%.	Sciencedirect	USA
49	De Oliveira. L, Coraucci. Runo, Roston. D, Stefanutti. R, Tonetti. A. Brazil, 2013	X	2013	Filtration efficiency - bioremediation of effluents	Case study - Experimental set up - pilot-scale systems	Evaluation of the Productivity of Irrigated Eucalyptus grandis with Reclaimed Wastewater and Effects on Soil	The area was divided into 28 sectors. The dimensions of each of the sectors of the planting were 9.0 m in widht and 12 m in length. In each sector, there were a total of 18 plants of the Eucalyptus grandis species. Test employed in the study are: In general, all are according to eucalyptus requirements and some modifications however, T1 without irrigation, T2 &T3 water source is pond water, T4, T5 and T6 is con effluent and fertilization NPK, and T7 only with effluent. Fertilizaters which was made every 6 months (200 kg/ha-1). Low throughput sprinkler was used for irrigation.	municipal, domestic or household wastewater	treated wastewater pond water and effluent from the facultative lagoon.	eucalyptus	SAR and sodium	The average rainfall in the city of Franca (Brazil) for the years in which the experiment was donducted reached 1668,7 +/- 150.6 mm year-1.	In the test with effluent irrigation, there was tendency t6o increase the concentration of sodium and the values of sodium adsorption ratio - SAR. The value found for sodium has increase after effluent irrigation, but SAR and exchangeable sodium percentage - ESP of the soil did not exceed the limit values presented in the literature, demonstrating that there was no risk of salinization so far.	Tests T6 and T7 had the highest productivity. The results demonstrate that there has been an increase of 82.9% in productivity of eucalyptus in relation to the generation of wood volume per hectare planted. The results demonstrate that when the treated effluent was utilized in irrigation of E. grandis the DBH, the commercial height of the plant (HT) and the wood volume were higher.	The behavior observed in this study may be related to hig rainfall rate observed in the yeras in which the research was conducted. In this case, there would be the expulsion of excess soluble salt introduced by wastewater, reducing of eliminating the risk of high soil salinity.	ResearchGate	Brazil
50	B. J. MYERS, S. THEIVEYANATHAN, N. D. O'BRIEN and W. J. BOND, Australia. 1995	X	1995	biomass production		Growth and water use of Eucalyptus grandis and Pinus radiata plantations irrigated with effluent	Pinus. radiata and Eucalyptus. grandis were planted at 2 - 3 m spacing (1667 trees ha-1). The pine plantation was established with cuttings from 12 genotypes. Trees in the medium (M) treatment were irrigated with effluent at the estimated water use rate of the plantation less rainfall. Trees in the high (H) treatment received 70–75% more effluent than trees in the M treatment, whereas trees in the low (L) treatment received nominally half as much effluent as trees in the M treatment. Trees in the fourth treatment were irrigated with bore water (W), also at the water-use rate of the plantation less rainfall. Each winter, 15–25 trees per species were harvested for biomass analysis. The maximum monthly mean daily water use by closed-can opy effluent-irrigated eucalypts of 7.5 mm day -1.	municipal, domestic or household wastewater	secondary-treated municipal effluent	Pinus radiata and Eucalyptus grandi	Mean annual rainfall at the site is 570 mm with a slightly winter-dominant distribution. Annual pan evaporation is 1860 mm, varying from a monthly low of 35 mm in June and July to a peak of 320 mm in January. Mean minimum and maximum temperatures are 3 and 31 °C, respectively. There is an average of 13 frosts per year. Soils consist of a sandy loam or sandy clay-loam A horizon (20–45 cm deep)	Both species grew rapidly when irrigated with either efflu ent or bore water. In the third year (when the eucalypts had a closed canopy), the eucalypts used 22% more water than the pines, but the annual mean leaf area index (LAI) of the eucalypts was three times greater than that of the pines. Total aboveground biomass at 3 years was 43.9 Mg ha-1, which is considerably higher than that others reported. The greater nutrient addition in the M treatment than in the W treatment resulted in faster develop ment of leaf area, greater volume and biomass accumulation, and higher predawn leaf water potentials in the eucalypts. The same response was not found in the pines, because the miner alization rate of the native N at the site was in excess of that required by the pine trees during their slow early growth. Volume growth of the eucalypts and pines in treatment	The growth of both E. grandis and P. radiata under effluent irrigation for 3 years at Wagga Wagga was high. closed-canopy eucalypts have a maximum monthly mean daily water-use rate of less than 8 mm day -1 and an annual crop factor between 0.84 to 0.93 times pan evaporation.		Australia		



51	Ajay Sharma, Nanjappa Ashwath, ???, 2004.	X	2009	Filtration efficiency - bioremediation of effluents	full-scale systems	Land disposal of municipal effluents: importance of choosing agroforestry systems	Plantations of seven agroforestry (AF) systems were raised in a two hectare experimental site at Yeppoon, 2002. The seven agroforestry systems were irrigated at 180 mm/ha/y as determined by the MEDLI (Model for Effluent Disposal using Land Irrigation). Apart from raising seven AF systems, i.e., bamboo (B), eucalypts (E), pangola (P), B+P, E+P, B+E, B+E+E in three replications (21 plots), two plots (B+E) were raised in diagonally opposite ends of the site for destrcutive studies at the end of experiment. Teh experimental plots covered 1,26 ha but for safety reasons total area cordoned was 2,1 ha. Each plot was irrigated with five sprinklers, which irrigated uniformly at most times.	municipal, domestic or household wastewater	municipal effluents	viz Pangola grass, Ma bamboo and Eucalyptus grandis or Flooded gum	The plantation site is located in a place where are being irrigated with municipal effluents and soils in the experimental site are red silty loam, this area gets an average annual rainfall of 1180 mm but had unusual dry season. Also the option of assumed gradual increase in vegetation cover up to 70% showed no change in soil chemistry. N and P content in the effluent is usually low.		Root densities in the first 30 cm under all agroforestry systems were similar, but in 30–60cm, Pangola systems had the highest root densities. In 60–100 cm depth, eucalypt based systems produced greatest density of roots. The study revealed that AF systems grew roots rapidly in all three depths examined. Highest rise in root density was observed under eucaypt based systems, followed by Pangola plots. It became evident that municipal effluent irrigated agroforestry plantations may offer a beter cropping model for community adoption in comparison to conventional monoculture plantations due to their similar capability in maintaining soil moisture as well as producing roots and offering an opportunity of additional commerical crops. AF systems that had bamboos developed higher soil moisture. Interestingly, there were exceptions. E+P maintained	The primary aim of the study was to identify an AF system that would efficiently use the applied effluent water and show the lowest seepage and soil degradation, while producing maximum biomass.	Sciencedirect	Yeppoon	
52	M. Tabari, A. Salehi., Iran, 2009	X	2009	Filtration efficiency - bioremediation of effluents	Case study - Experimental set up - pilot-scale systems	The Use of Municipal Waste Water in Afforestation: Effects on Soil Properties and Eldar Pine Trees	The experiment was conducted at two 4 hectare even-aged (15 years) artificial stands of Pinus eldarica Medw. The first stand was irrigated with municipal waste water and the second with well water since planting. The irrigation was applied daily based on tree water-use and the potential evapo-transpiration. wastewater were alkaline in reaction 7.5-7.75. electrical conductivity 1.8-2.12 dSm-1. The concentration of all the nutrient elements was higher in wastewater.	municipal, domestic or household wastewater	Municipal wastewater	pine	N, P, K, Ca, Mg, Na, Cu, Fe, Mn, Zn, pH, EC, SOC, CaCO3	semi-arid with mild-cold winters and a 7-month (mid-april to mid-november) dry season. Average annual rainfall and average annual temperature are 232 mm and 13.3°C, respectively. The highest rainfall appears in March and the lowest in August. The warmest month occurs in August and the coldest in January.	The study for 15 years showed the enrichment of soil with nutrients without excesive accumulation of studied elements in soil and plant.	This study confirms that municipal waste water could be utilized as an important source of water and nutrients in growing P. eldarica to increase biomass production. Application of municipa wastewater facilitad the availability of valuabe essential nutrients and water in soil. Tree growth was greater in the field irrigated using municipal waste water.	This study confirms that municipal waste water could be utilized as an important source of water and nutrients in growing P. eldarica to increase biomass production. The objective of this study was to investigate the effects of 15-year municipal waste water application on the growth of eldar pine (Pinus eldarica Medw.) trees and mineral accumulation in tree needles and soil.	ResearchGate	Iran
53	H.Al-Hamaiedeh, M.Bino. Jordan, 2010	X	2010	Filtration efficiency - bioremediation of effluents	full-scale systems	Effect of treated grey water reuse in irrigation on soil and plants	Soil sampling was conducted twice a year for two years starting from February 2006. The samples were collected from five designated home gardens irrigated with greywater. Six soil samples were collected from each garden, three samples from the surface layer at depths of 0 to 30 cm and the other three at depths of 30 to 60 cm.	municipal, domestic or household wastewater	treated grey water (GW)	olive	pH, total suspended solids (TSS), biological oxygen demand (BOD5), chemical oxygen demand (COD), total nitrogen (T-N), nitrate as well as cadmium (Cd) and lead (Pb)	Mediterranean climate, that is characterized by dry and hot summer seasons from May to September with a max temperature of 34 °C and wet winter season extending from October to April with a mean temperature of 14 °C. The mean annual rainfall is about 340 mm, the average wind speed is about 7.2 km/h and the evaporation average is 13.3 mm/day.	the quality of treated GW complies with Jordanian standard for irrigation of fodder crops (category C) and tree crops (category B), but does not meet the standard for irrigation cooked vegetables (category A). The macro and micro elements decreased with the sol depth.	Composite 5 samples of fresh olive leaves and fruits were collected from five gardens irrigated with GW. There is no evidence of chemical impact on leaves and fruits of olive and crops due to irrigation with GW. Olive trees are the prevailing plants in the study area and are classified as moderately salt tolerant plants. This makes the reuse of treated GW for olive trees irrigation of high potential in the study area. However, long-term use of reclaimed water can lead to salt and metal accumulation in the soil and subsequent uptake by the plants. there is greater mineral concentrations in leaf which were irrigated with waste water.	The 4-barrel unit (Fig. 1), consists of four plastic barrels made from high density polyethylene (HDPE). In the first barrel that receives GW from the house, grease, oil and settleable solids are removed. The second and third barrels were filled with gravel filter media of 2 to 3 cm diameter. . The fourth barrel was fitted with a small electric submersible pump and float switch to deliver treated GW to a trickle irrigation system. Soil leaching with fresh water is highly	Sciencedirect	Jordan

54	G.Khurelbaatar, C.M.Sullivan M.van Afferden K.Z.Rahman C.Fühner O.Gerel J.Londong R.A.Müller, Mongolia, 2016	X	2016	Filtration efficiency - economic	Case study - Experimental set up - pilot-scale systems	Application of primary treated wastewater to short rotation coppice of willow and poplar in Mongolia: Influence of plants on treatment performance	2 years under the same operating condition (with a daily hydraulic load of 5 mm). The pilot plant consisted of a sewerage interception and diversion system, a primary settling tank, four treatment beds, a planted control area, and a sampling manhole.	municipal, domestic or household wastewater	pre-treated domestic wastewater	willow and poplar	CSB, BOD5, TN, NH4-N, NO3-N and TP	The mean daily minimum and maximum temperatures range from −33 °C to −15C° in January and from 10 °C to 32 °C in July, respectively. In this region main rainfall events occur in summer. When compared to the long term mean precipitation of 265 mm (MoMo, 2009), both years 2012 and 2013 experienced a higher amount of rainfall of 364 mm and 492	An average mass removal rate of 241 ± 14 g m−2 a−1 (86% removal efficiency), 130 ± 26 g m−2 a−1 (93% removal efficiency), 82 ± 11 g m−2 a−1 (80% removal efficiency) and 7.1 ± 1.2 g m−2 a−1 (85% removal efficiency) was observed for COD, BOD5, TN and TP respectively in planted bed over two study years.	the planted bed irrigated with pre- treated wastewater showed greater tree growth (height, biomass yield) as compared to the plants that were grown within the control area without any additional irrigation (i.e. natural growth).	Sciencedirect	Mongolia
55	Ziqing Oua, Tieheng Suna, Peijun Lia, Ayfer Yedilerb, Guifen Yanga, Antonius Kettrup. China, 1997	X	1997	Filtration efficiency - economic	Case study - Experimental set up - pilot-scale systems	A production-scale ecological engineering forest system for the treatment and reutilization of municipal wastewater in the Inner Mongolia, China	It occupied a field area of 880 ha for a daily treatment flow of 10 000 m3 of municipal wastewater from the whole city of about 50 000 people. The system consists of five sub- systems with the main technological treatment process of 'wastewater→primary treatment→LTS' and 'wastewater→primary treatment→(winter) storage in reservoir→LTS'.	municipal, domestic or household wastewater	municipal wastewater	larch, pine, poplar	BOD5, COD, total nitrogen and total phosphorus	less precipitation (389 mm yr−1) than evaporation (1495 mm yr−1). The climate in this arid area is characterized by cool and short summers (about 41 days) and cold and long winters (about 173 days).	Concentrations of BOD5, COD, total nitrogen and total phosphorus in the percolation water were in the range of 1–3, 20–30, 0.5–1.5 and 0.03–0.06 mg l−1 and their removal rates were greater than 86, 65, 85 and 84%, respectively.	the system performed well and trees grew much better than in the control (0.5–1.2 m higher for poplar and 0.1–0.2 m higher for larch).	Sciencedirect	China
56	Pay Drechsel and Munir A. Hanjra	X	1998	Filtration efficiency - economic	Case study - Experimental set up - pilot-scale systems	Wastewater for fruit and wood production (Egypt)	The Greater Cairo Sewage Water Company (GCSWC) operates the El Berka wastewater treatment plant in the north-eastern part of Greater Cairo. Although the bulk of its wastewater is discharged back into the environment, about 5% of its secondary treated wastewater is used for irrigating lemon trees, cactus and trees for wood production, such as Khaya senegalensis, and, on pilot basis, industrial oilseeds including Jojoba and Jatropha. In addition, about 1,500 tenant farmers renting government land use approximately another 12% of the treated wastewater to irrigate about 1,000 hectares (ha) to support their livelihoods. only a minor part of the generated wastewater is formally used to irrigate fruits (lemons, cactus) and different wood producing trees (e.g. Cupressus sempervirens, Kaya senegalensis). Since 2007, when lemon and cactus were commercialized for the first time, the actual area under irrigation	municipal, domestic or household wastewater	household wastewater	lemon trees, cactus		Egypt has an arid climate with an annual precipitation in Cairo of only 26mm.		In general it is a BUSINESS MODEL CANVAS FROM THE OPERATORS' PERSPECTIVE.	IWMI - International water management institute	Egypt



57	M. Liesebach, G. von Wuehlisch, H.-J. Muhs		1999	Filtration efficiency - economic but NO wastewater application	<b>Economic evaluation - to calculate the economics</b>	Aspen for short-rotation coppice plantations on agricultural sites in Germany: Effects of spacing and rotation time on growth and biomass production of aspen progenies	The basis of this project are two trial plantations, one in Bavaria (south Germany) and the other in Hesse (central Germany). At the trial plantation in Bavaria (Abbachhof), six aspen progenies were planted in 1983 and tested for their suitability in different short-rotation periods (5 and 10 years) and three different spacings. At the other location in Hesse (Canstein), 14 aspen progenies were planted in 1986 and tested in a 10-year rotation period at one spacing. At Abbachhof three different planting densities, with 8333, 5555 and 4167 plants per hectare and two-rotation periods of 5 and 10 years. In Canstein only one planting density (4167 trees per hectare) and one-rotation period (10 years). Abbachhof (2.0 m x 0.9 m and 2.0 m x 1.2 m spacing) and Canstein (2.0 m x 1.2 m spacing).	water		Populus tremula L P. tremuloide s Michx		yearly average precipitation is 650 and 675 mm and temperature 88 and 7.58C.		The relatively low production of ca. 15 t absolute dry matter per hectare in the ninth and tenth year (1994, 1995) at Canstein. In winter 1987/1988, Abbachhof, for the first-rotation period yielded between 7 and 34 t absolute dry biomass per hectare. At Abbachhof, several poplar clones produced between 20 and 40 t absolute dry biomass per hectare in the first five-year rotation period. The total biomass production in two five-year rotation periods was less than in the 10-year rotations which were established with a smaller number of plants. For Miscanthus plants two years and older dry matter yields in Germany and Denmark ranged from 11 up to more than 40 t per hectare. Second year crop yields in the UK ranged from 2 to 24 t dry matter per hectare depending on planting density. In Europe, production values of 11 to 18 t dry matter per hectare are	The species of the genus Populus and Salix are known for their fast juvenile growth. Where planting densities for short-rotation coppice plantations are concerned, a spacing of 2.0 m x 0.9 m with ca. 5555 plants per hectare and also a spacing of 2.0 m x 1.2 m with ca. 4200 plants per hectare have proven to be recommendable.		Germany
58	H.Rosenqvist, P.Aronsson, K.Hasselgren, K.Perttu	X	1997	Economic - avoided costs - value added opportunity - profitable	<b>Economic evaluation - to calculate the economics</b>	Economics of using municipal wastewaters irrigation of willow coppice crops	The general aim of this paper is to illustrate a realistic way of handling and utilising this resource in a recirculation system, applying a combination of waste water treatment and biomass production.	municipal, domestic or household wastewater	Wastewater	willow		The possibility of reducing the costs for conventional N and P treatment (70-180 SEK (kg N) -1) is by far the most important economic factor when considering wastewater irrigation of willow cultivations as an alternative treatment technique.	The wastewater application corresponds to 104 kg N ha-1 yr-1 and is estimated to increase biomass production by 2 tDM ha-1yr -1. The increased biomass production and the reduced costs for the farmer (corresponding to 13 SEK (kg N) -1) have a limited impact on the economical result.	An increased biomass production probably enables an increased N-application without risks for N-leakage. An increased wastewater application rate would also reduce the costs per kg treated N if the same equipment could be used. However, distribution and storing of larger volumes of wastewater would probably involve more expenditure for pump and storage capacity. In a warmer and dryer climate, such as in southern	Sciencedirect	Sweden	
59	H.Rosenqvist, M.Dawson	X	2005	Economic - avoided costs - value added opportunity - profitable	<b>Economic evaluation - to calculate the economics</b>	Economics of using wastewater irrigation of willow in Northern Ireland	This paper calculates the added value in terms of avoided costs for the chemical and or physical treatment of the wastewater, and the avoided costs for fertilisation of the coppice and yield improvements due to the fertilisation and irrigation effects of the application of the wastewater. This paper, using an economic model developed by Rosenqvist, investigates the economic benefits.	municipal, domestic or household wastewater	Wastewater	willow		However, increased biomass production would allow increased N-application without risk of N-leaching.		It is likely that a doubling of the rate used in the calculation for the main case with or even higher doses of wastewater would lead to substantial N-leaching. Such high doses could also lead to water saturation of the soil, and thereby a lack of oxygen in the root zone, which would harm the plants and lower biomass production. Even if leaching increased at a higher level of irrigation (with nutrient availability in excess of that required by the short rotation	Sciencedirect	Ireland	

60	H. Rosenqvist, M.Dawson	2004	Economic - avoided costs - value added opportunity - profitable but NO wastewater application	Economic evaluation - to calculate the economics	Economics of willow growing in Northern Ireland	This paper reviews the e economics of short rotation coppice willow as an energy crop in Northern Ireland. The cost estimation model for different crops. The main calculations in this paper are made without inclusion of opportunity cost for land or subsidy for growing the crop. All costs for workforce and machinery are included in the calculations.	water	water	willow					Currently the industry in Northern Ireland is at a very early stage of development and this imposes cost penalties on the pioneer growers. This situation is compared with the situation in Sweden where there is an established industry of 15,000 ha, where costs are significantly lower. Gross margin for the pioneer grower in Northern Ireland is about £100 ha-1 yr-1 less than for Swedish willow growers.	Sciencedirect	Ireland
61	Janine Schweier, Gero Becker	2013	Economic - avoided costs - value added opportunity - profitable but NO wastewater application	Economic evaluation - to calculate the economics	Economics of poplar short rotation coppice plantations on marginal land in Germany	Therefore, the aim of this study is to analyse the economy of a typical SRC supply chain by calculating the annuities which can be expected by German farmers who establish SRC on their marginal land. In 2009, an experimental SRC of 4.5 ha was established with poplars (Max 4 and Monviso) in the mountainous region Schwa'bische Alb (630 m above sea level) in southwest Germany. The distance between the rows is 250 cm and the distance between trees within a row is 60 cm, resulting in an initial planting density of 6700 trees per ha. Input data for this study were collected to a large extent on the experimental SRC plantation, e.g. the working time required for specific processes, costs of the cuttings, the amount and costs of herbicides used for soil preparation or the annual costs for land rent. The resulting NPV is 863 € y-1 ha- 1. Considering the current market price of 90 € Mg-1 dm this results in an annuity of 69 € y-1 ha-1.	water	water	poplar	The average soil quality index of the site is 37, the average air temperature is 7.2 °C and precipitation is 790 mm per year on average (466 mm in the growing season)	The amount of biomass corresponds to an average yield of 7.6 Mgdm y-1 ha-1. This result is rather low compared to yields reported in other European studies. However, the sensitivity analysis performed considers a range of biomass yield figures per harvest corresponding to average yields between 7 and 14 Mgdm y- 1 ha-1. Today, in most cases SRC are harvested with a combined cut and chip system, using modified foragers equipped with special wood biomass header. In this case, the MC of fresh wood chips is up to 50-60%. Accordingly, the heating value is lower (ca. 8.3 GJ Mg-1 dm) which results in a lower market price (90 € Mg-1 dm).	To achieve higher annuities, four options were analysed possibly leading either to higher biomass yields or to higher market prices (extension of rotation cycle, implementation of irrigation, technical drying of fresh wood chips, using a two-step harvesting system). Results also show that the technical drying of chips using (cheap) surplus heat can be very profitable if the added value is reflected in higher market prices. Furthermore, it is shown that the use	Sciencedirect	Germany		
62	C.P. Mitchell, E.A. Stevens, M.P. Watters	1999	Economic - avoided costs - value added opportunity - profitable but NO wastewater application	Economic evaluation - to calculate the economics	Short-rotation forestry – operations, productivity and costs based on experience gained in the UK	In the UK, the ability of short- rotation coppice to compete with conventional agricultural crops is still heavily dependent on the subsidies available for short-rotation coppice and the crop in question. a computer model called BEAM were used to determine appropriate supply strategies. The results indicated that although shoots lost less dry matter during storage than chips, the costs of production outweighed any gain. The economics of SRC plantations has been studied using spreadsheet models. In order to study the financial viability of the plantation all costs are put into a cash-flow stream which is discounted so as to account for the effect of time.	water	Wastewater	willow and poplar	Ideally, SRC should be established on well-drained, fertile soil, on a site which is "at and free from stones.	Analysis of a wide range of data from field trials in Europe and North America showed that average levels of productivity ranged from 2 to 13.5 odt/ha/year. Figures of up to 36 odt/ha/year have been recorded for willow growing under optimal water and nutrient conditions.Average productivities from SRF plantations in countries as: USA, Canada, Dermark, Finland, Sweden, Australia and UK where the productivity is between 2,1 - 1,3.5 odt/ha/year. Also there are some Recommendation about willow clones for use in SRC in the UK and poplar clones for use in SRC in the UK.	It is difficult to compare SRC plantations with traditional agricultural crops because of the relatively long time scale that the crop is grown for and the lengthy payback period. Realism is creeping in, lower yields than anticipated are being accepted, matched by lower costs, thus, allowing short- rotation coppice to become viable at a commercial scale, especially if grants and subsidies are available. Of course, this still begs the question as to whether there	Sciencedirect	UK		



63	H akan Rosenqvist, Barry Ness		2003	Economic - avoided costs - value added opportunity - profitable	<b>Economic evaluation - to calculate the economics</b>	An economic analysis of leachate purification through willow-coppice vegetation filters	In this study an economic analysis of the purification of integrated solid waste treatment facility leachates through a willow coppice (Salix) vegetation filter in southern Sweden was carried out. Calculations were based on the use of two computer models (The first model employed was used for calculations of the irrigation equipment and came from Rosenqvist and The second cost estimation model was developed for applications predicting the financial outcome for willowcoppice grown for energy production) that were initially used in estimating a pump- and-pipe irrigation system for a 36- ha willow-coppice plantation to purify an average annual quantity of 195,000 m3 of leachate with an average nitrogen content of 24 g/m3.	landfill leachate	lechate	willow	The Filborna facility is the principal integrated waste treatment and recycling complex operated by Northwest Scanian Recycling Company (NSR). The Filborna facility originally opened as the regional landfill for the area. the Filborna bioreactor cell accepted just over 107,000 tons of mixed waste. A system that treats all facility leachates through the vegetation filter may not be the	There are at least two environmental benefits associated with treating leachate in willow- coppice filter systems. As demonstrated by Hasselgren (1999), the initial benefit is the purification rates are higher in the soil willow system than in conventional treatment facilities, which ultimately results in the release of fewer macronutrients into waterways than the conventional treatment. The second benefit is increased production of biofuels which has		there is a cost savings of US\$77.2/ha/yr with the increased savings from both the leachate fertilisation regime and the increased income from the annual 2 tons/ha yield increase. Thus, the grower who uses a wastewater irrigation system with willow- coppice crop is compensated US\$77/ha/yr or US\$0.014/m3 of available leachate. The treatment cost for each cubic meter of available leachate is US\$0.34/m3, and can be reduced further by	Sciencedirect	Sweden
64	Karin Ericsson, Håkan Rosenqvist Lars, J.Nilsson, 2009	X	2009	Economic - avoided costs - value added opportunity - profitable	<b>Economic evaluation - to calculate the economics</b>	Energy crop production costs in the EU	The objective of this study was to calculate indicative ranges of production costs and assess the main sources of cost for a number of energy crops, both annual and perennial, on a regional level in Europe. The production costs were calculated in terms of the economic compensation required by the farmer in order to grow the crop, and therefore include not only the cost of cultivation, but also the costs of land and risk, which are often omitted in production cost calculations.	municipal, domestic or household wastewater	Wastewater	eucalyptus, willow and poplar	The geographical scope of this study is Europe, which was divided into six regions: Northern1, Western2, Southern3 and Eastern4 Europe, the Alps5 and the UK & Ireland.		The price of biomass is determined mainly by market energy prices (including effects from energy and environmental policies), in particular those of fossil fuels. The price of unrefined biomass such as wood chips is about 4–5 € GJ–1 in Europe.	The energy crop production costs calculated in this study are consistently lowest for SRC crops and highest for annual straw crops. production costs are lowest for the energy crops that are associated with the highest costs of risk and the largest changes at farm level in terms of workload and machinery.	Sciencedirect	EU
65	Józef Mosiej, Agnieszka Karczmarczyk and Katarzyna Wyporska, Aleh Rodzkin, 2012		2012	biomass production but NOT wastewater application	<b>Case study - Experimental set up - pilot-scale systems</b>	Biomass Production in Energy Forests Short Rotation Plantations	Energy forest is not a main alternative for biomass pro duction in EU. Only few countries have a sizeable stand of SRPs. Swedish plantations seem to be the largest, al though it only amounts to about 14,000 ha which trans lates to about 0.5% of the total arable land in the country and currently contributes about 1% of Sweden's wood fuel requirements. In Poland in 2009 it was 8 700 ha. . The land suitability for willow, poplar and Miscanthus cultivation has been estimated to be 353,000 ha in Estonia, 481,000 in Latvia and 1,332,000 ha in Lithuania, or 19%, 7.5% and 20.6% of the available agricultural land, respectively.	water	wastewater	willow		In general reduction of total phosphorus was high (84%) and reduction for total nitrogen medium (47%).	o get 20 Mg of dry willow biomass per hectare, about 150 kg of nitrogen, 18 kg of phosphates and 60 kg of potassium are needed.	with a good organization, SRPs are economically a good choice. The concentration of willow plantations to a rela tively small area will scale up the operations enough to allow the farmers to establish an industrial infrastructure for processing willow biomass and distribute the pro duced wood chips in the most cost-effective way. Reliance on locally produced biomass is an advanta geous economic solution for energy supply. Compared to being	ResearchGate	EU

66	L. Christersson and K. Verma, 2006	X	2006	Filtration efficiency - economic	Case study - Experimental set up - pilot-scale systems	Short-rotation forestry – a complement to “conventional” forestry	The present article summarizes observations made at a session on “Wood production in agroforestry and in short-rotation forestry systems – synergies for rural development” at the XXII International Union of Forest Research Organizations (IUFRO) World Conference in Brisbane, Australia, in August 2005. It describes cases in which as many limiting factors as possible are taken away to achieve maximum growth rate of trees, demonstrating the potential of the practice. Examples include poplar in the United States, Canada and India, willows in Sweden, bamboo in China and Ethiopia and eucalypts in Australia and Brazil. Examples from some other countries recognize further opportunities for short-rotation forestry	municipal, domestic or household wastewater	effluent wastewater from towns and industries	willow, Eucalyptus, poplar, bamboo	N, P and heavy metals		large amounts of nitrogen, phosphorus and heavy metals, which some willow clones are able to absorb efficiently.	Australia, The total above-ground biomass production, including leaves, is about 10 tonnes per hectare annually. China, there are some 1500 bamboo species. The annual above-ground production may reach 30 to 40 tonnes of dry matter per hectare at different rotations. Ethiopia, some 12000 ha of Eucalyptus and hundreds of thousands of hectares of bamboo could be used to filter wastewater used for irrigation and fertilization. In experiments with plantations of Eucalyptus species carefully selected for rapid growth, irrigated with effluent wastewater from towns and industries, annual production of up to 40 tonnes of dry matter per hectare has been reported in southeastern Australia (Baker, Duncan and Stackpole, 2005).	The establishment of vegetation filters, in which nitrogen and phosphorus in waste water and sewage are used for irrigation and fertilization in short-rotation forestry, can be of particular interest in developing countries where technically advanced purification plants are too expensive to establish. Vegetation filters also help prohibit eutrophication (nutrient pollution) of nearby streams and lakes.	FAO	EU
67	I.D.PulfordC.Watson, 2003		2003	Filtration efficiency - economic but NO wastewater application	Case study - Experimental set up - pilot-scale systems	Phytoremediation of heavy metal-contaminated land by trees—a review	This paper reviews the potential for using trees for the phytoremediation of heavy metal-contaminated land. It considers the following aspects: metal tolerance in trees, heavy metal uptake by trees grown on contaminated substrates, heavy metal compartmentalisation within trees, phytoremediation using trees and the phytoremediation potential of willow ( <i>Salix</i> spp.).	water		willow	heavy metal Cd, Ni, Zn, Lead, chromium and copper		The use of trees as a vegetation cover for the phytoremediation of land contaminated by heavy metals does seem to have considerable potential. Survival seems to be due to facultative tolerance, such as avoidance by roots of highly contaminated substrate or by immobilisation of heavy metals in the root. There is, however, some evidence that tolerance may be increased by acclimation of individual trees to low concentrations of heavy metals.	Lead, chromium and copper tend to be immobilised and held primarily in the roots, whereas Cd, Ni and Zn are more easily translocated to the aerial tissues. The main characteristic of trees that makes them suitable for phytoremediation is their large biomass, both above and below ground. The large willow breeding programmes, for example in Sweden and the UK, provide the opportunity to produce clones that have suitable characteristics for phytoremediation—especially high biomass production, high metal uptake and tolerance.	Collaboration with universities, research institutes and government bodies could create the multidisciplinary teams necessary to address questions such as: the agronomic practices needed for successful establishment of vegetation, development of plants for specific remediation requirements, the question of what constitutes ‘clean-up’ (bioavailable vs. total), effects of growing plants on the wider environment and fate and disposal of high metal	Sciencedirect	EU
68	J.G. Isebrand, J. Richardson, 2014	X	2014	Filtration efficiency - economic	Case study - Experimental set up - pilot-scale systems	Poplars and Willows	In this book shows different example of irrigation with wastewater in Canada, Estonia, Korea, New Zealand, Sweden, UK, USA. Erosion prevention and riverbank stabilization are still the most important uses of poplars and willows.	municipal, domestic or household wastewater	Industrial and municipal wastewater	poplar		although native willows are adapted to wetter sites than native poplars, growth on poorly drained soils may be non-economic.	Poplars are demanding of high nutrient levels and generally are established on relatively fertile sites. In some places, municipal effluent and biosolids have been used; biosolids have been beneficial especially on marginal soils. Use of treated wastewater is more common in willow bioenergy plantations	Moreover, members of the Salicaceae family show an impressive acclimation ability in response to most stresses. The global consumption of biomass for energy increased by 51% between 2006 and 2009. Globally, around 8.6 million ha of planted forests, of which 6.7 million ha (78%) are in Asia, are being grown specifically for wood fuel.	The highest levels of poplar productivity have been obtained when N supply is adequate and other nutrients are kept in balance with N to avoid relative deficiencies. There are various barriers such as institutional, structural and technical/geographical. The cultivation of short-rotation bioenergy plantations was introduced in Sweden after the oil crisis in the 1970s, with the intention of replacing fossil fuels by renewable, carbon dioxide neutral	FAO	EU



69	NIKOLAOS V. PARANYCHIANAKIS and ANDREAS N. ANGELAKIS, HAROLD LEVERENZ and GEORGE TCHOBANO, 2006	X	2006	Filtration efficiency - bioremediation of effluents	Case study - Experimental set up - pilot-scale systems	Treatment of Wastewater With Slow Rate Systems: A Review of Treatment Processes and Plant Functions	Slow rate systems purify the applied wastewater through physical, chemical, and biological mechanisms that occur concurrently in the soil–water–atmosphere environment. These mechanisms include filtration, transformation, degradation, predation, natural die-off, soil adsorption, chemical precipitation, denitrification, volatilization, and plant uptake . This article reviews the treatment processes that occur during land application of wastewater effluent, the role of vegetation, and the appropriate management practices to ensure long-term performance of SRS, environmental protection, and the sustainability of the land.	municipal, domestic or household wastewater	wastewater	Currently, a variety of annual crops, perennial grasses, and forest trees are used in SRS worldwide, (eucalyptus , populus, willow, red maple)		SRS are capable of efficient wastewater treatment in a wide range of climatic conditions, varying from extremely hot and dry climates to cool and wet.	Primary effluent with a BOD/N ratio >3 should be used to support nitrification and denitrification processes. To maintain the BOD/N ratio within the optimum range, only primary sedimentation or equivalent treatment is required. Tolerance to salt are pinus radiata, some eucalyptus, 2 species of acacia, 1 of populus). Typical organic loads applied to SRS receiving domestic wastewater fluctuate from 50 to 100 kg BOD/ha	Potential of Biomass Production and Nutrient see table 7. The uptake rate of nutrients and their accumulation in aboveground biomass may differ greatly among plant species and can often compensate for differences in biomass production. Indeed, trees of Eucalyptus botryoides displayed a greater removal of nitrogen and phosphorus than Eucalyptus ovata, despite their lower production of biomass. Planting density in a short-rotation coppice may vary from about 1000 to more than 100,000 trees per hectare.	Vegetation has an important role in treatment efficiency through its effects on hydraulic loading rate, nutrient removal, and biomass production. Generally, nutrients are abundant in most wastewater effluents and do not appear to limit the growth of heterotrophic microorganisms, which are responsible for organic matter mineralization. The capacity of vegetation to remove nutrients varies greatly among plant	ResearchGate	EU
70	Arne Backlund, 2015	X	2015	Filtration efficiency - bioremediation of effluents	Case study - Experimental set up - pilot-scale systems	Short-rotation Willow Biomass Plantations Irrigated and Fertilised with Wastewaters	Willows were planted on an area of up to 5 hectares at each experimental site. Within the experimental field, sub-plots were placed with different treatmentsrandomised in each of three replicates. The sub-plots were planted with theSvalöf Weibull AB variety “Jorr” (Salix viminalis). Guard rows, to give at leasta 20 m buffer zone between each plot, were planted at the same density withthe same clone (Sweden and France) or a mixture of S. viminalis clones(Culmore). Guard areas in Greece were left in grass.Three replicates resulted in 12 to 18 plots in total per site. The plot size was16 m x 25 m = 400 m2 resulting in plot width of 7 double-rows (7 x 2.25 m =15.75 m) and the length equivalent to a row of some 40 plants. The totalnumber of plants was approximately 600 per plot. The experimental fields at Roma, Culmore and Larissa were all irrigated withmunicipal wastewater.	municipal, domestic or household wastewater	primary effluent from municipaltreatment plants	willow	main nutrients (nitrogen(N ), phosphorus (P) and potassium (K))	Northern European local-maritime climate with relatively low, evenly distributed precipitation, and a high amount of sunshine hours (Roma) Central European local-continental climate with evenly distributed precipitation (Orchies) Typical western European maritime climate with mild, wet winters and relatively cool summers (Culmore) Typical	Table 12. Wastewater treatment effects for Culmore in terms of nitrogen (Total N), phosphorus (Total P) and BOD. Corrections (corr) were made for percolation from rainwater control plots.	The estimated biomass production the first year at Orchies averaged 3.5 tDM/ha. The survival rate was 91.2 %. At Roma, on average during 2001, the growth was 11.4 t DM/ha with the lowest growth, 7.5 t DM/ha. In general, growth results recorded in this study were at higher levels than those of otherproduction results from commercial plantations in Sweden. During the winters 1995/96 and 1996/97, some 1600 hectares of willow plantations in southern Sweden were harvested. The stem growth of the 4-year stands varied between 2 and 15 t DM/ha/y with an average of 4.8 t DM/ha/y.	This report summarises results and experiences gathered from field trials withrecycling of pre-treated wastewater, diverted human urine mixed with water, and municipal sludge, within plantations of willow species specifically selectedfor biomass production. Experimental sites were established in Sweden(Roma), France (Orchies), Northern Ireland (Culmore) and Greece(Larissa). The project was carried out during a 4-year period with	ResearchGate	EU
71	Isabel Malico, Ricardo Nepomuceno Pereira, Ana Cristina Gonçalves, Adélia M.O.Sousa, 2019		2019	Filtration efficiency - bioremediation of effluents but NO wastewater application	Case study - Experimental set up - pilot-scale systems	Current status and future perspectives for energy production from solid biomass in the European industry	A review of the technologies available for its conversion and of the feedstock production, consumption and characteristics. This work combines these issues into a single review, providing the reader with an integrated, synthesized overview and allowing a comprehensive understanding of the perspectives for additional use of biomass by industry. Although this is done in a European context, several topics covered in this paper are also relevant when assessing the potential of further industrial biomass use in other regions. Additionally, the deployment of further biomass by the EU28 industry is likely to be linked to imports and to affect other world regions that export biomass, increasing the pressure on their natural resources.	water	willow				The EU28 industrial sectors that consumed the most solid biomass for process heat are those that generated biomass residues, such as the pulp, paper and printing; and the wood and wood products industries, which were responsible for 85% of the industrial biomass final energy consumption. Of some relevance is the non-metallic mineral sector, which, despite not generating biomass residues, accounted for 6% of the EU28 biomass consumption for process heat. In EU28, the energy production from solid biomass increased by 134% from 1990 to 2017. In 2017, the primary energy production from solid biomass (excluding charcoal) was 3986 PJ, which corresponded to 12.5% of the total primary energy production and 69% of the biomass primary energy production.	The largest contribution for solid biomass fuels comes from the woody biomass. In EU28, 22% was used as fuelwood. To date, pellets are the upgraded biofuel mostly used in Europe = 9% of the total solid biomass energy consumed in EU28, corresponding to around 21.7Mt. The largest producers of wood pellets are Germany, Sweden, Latvia, France, Estonia, Austria, Portugal, Poland, Romania and the Czech Republic. In 2017, 22% of the EU28 solid biomass energy corresponded to	Sciencedirect	EU	



72	Nicolas Marron, 2015	X	2015	Filtration efficiency - bioremediation of effluents	<b>Case study - Experimental set up - pilot-scale systems</b>	Agronomic and environmental effects of land application of residues in short-rotation tree plantations: A literature review	I attempt here to compile and to summarize the results of the studies about the effects of land applications of residues (mostly organic) in plantations or under controlled pot conditions of the three species mostly used for short-rotation coppice: willow, poplar, and eucalyptus. Manure, compost, sewage sludge, and wastewater seem most effective in stimulating growth. The industries involved are various: textile, tannery, paper mill, dairy, pharmaceutical, pesticide, wood industry, distillery, steel, etc. However, studies concerning each of the different types of industries are very few.	municipal, domestic or household wastewater	the studies about land applications in SRC plantations concern sewage sludge and wastewater (including industrial effluents). Overall, the effluents are for a quarter of industrial origin and three quarters of municipal origin.	willow, poplar, and eucalyptus	The quantities of land applied residues are also very variable and are often expressed in different terms: dry weight, fresh weight, volume, content of an element (N, P, etc.) or a pollutant (Cu, Zn, etc.)		Some studies mention performances multiplied by two or three in response to the effluent application. 14% of studies have shown contamination effects of land application for the plant or the environment.	The most frequently described species are Eucalyptus globulus, Eucalyptus grandis, Populus deltoides, Populus × euramericana, and Salix viminalis. In general, wastewater did not cause short-term damage on plants and stimulated the growth of poplar, willow and eucalyptus. Notably, wastewater rich in nutrients and organic matter caused a gain in biomass of 143% for eucalyptus, 54% for poplar, and 274% for willow. Domestic wastewater stimulated growth of poplars more than municipal wastewater and control water, due to more favorable nutrient and organic matter contents and lower levels of pollutants.	The studies can be roughly classified into two categories depending on the purpose of the application: (1) to fertilize the trees while valorizing a residue, or (2) to get rid of industrial residues, often polluted, trying to limit the impact on the environment and to sequester in trees, for more or less long periods, the undesirable elements present in the effluents. Few negative effects on the plant have been highlighted in response to spreading, except in the case of very rich effluents in salt in response to	Sciencedirect	EU
73	Center for recirkulering, 2000	X	2000	Effects on soil, Filtration efficiency - bioremediation of effluents	<b>full-scale systems</b>	Willow Wastewater Cleaning Facility with zero discharge	facilities from 8 x 6 m to 8 x 60 m. to plant willow cuttings. This has to be done in early spring and the wastewater has to be added right after planting. In this way the willowtrees will grow up and empty the soil during spring summer and autum.	municipal, domestic or household wastewater	waste water	willow			Nutrients and heavy metals are effectively uptaken in the willow stems and foliage and approx. 10- 20 !! tonnes of dry matter per hectare are produced.	Willow will only be usable for the purpose in temperated areas and southern parts of arctic areas and only in both areas with special selected clones of willow (it is not meantmodified clones). Willow need winter to grow, but there are clones usable also for areas with short summers. If willow trees are used for energy the content of heavy metals in ashes has to be taken in consideration.	From household wastewater it is not a problem because the content per weight unit is at the same level or lower than in natural grown tree.	Sciencedirect	Denmark
74	Maja Zupancic Justin, Nastja Pajk, Vesna Zupanc, Marija Zupancic, 2010		2010	Phytoremediation	<b>Case study - Experimental set up - pilot-scale systems</b>	Phytoremediation of landfill leachate and compost wastewater by irrigation of Populus and Salix: Biomass and growth response	The irrigation owver a 1-year growing period, daily. . 25 cm long cuttings were processed from young, 1-year old shoots of a P. deltoides tree and two Salix trees. Before planting, cuttings were soaked in water to a height of 20 cm for 1 day. Cuttings were planted in 12 L pots filled with a compost–soil mixture in the range of 1:2 on a volume:volume basis. The upper 5 cm of each cutting was left above the substrate. Plastic mesh was placed on the bottom of each pot in order to prevent roots from growing outside the pots and to prevent substrate from washing-out of the pots.	landfill leachate	landfill leachate and compost wastewater	willows and poplar			High nutrient load indicates high potential for phytoremediation of Salix and Poplar plantations.	The use of leachate resulted in up to 155% increased aboveground biomass compared to control water treatments and in up to 28% reduced aboveground biomass compared to a complete nutrient solution. The use of compost wastewater resulted in up to 62% reduced aboveground biomass compared to the control treatments and in up to 86% reduced aboveground biomass compared to the complete nutrient solution. Populus was the most effective in biomass production due to the highest leaf production, whereas S. purpurea was the least effective in biomass accumulation. The greatest total tree biomass was achieved by P. deltoides in the Opt treatment. Landfill leacahte positively affected growth of Salix and Populus and increased biomass production due to the fertilization/irrigation properties of wastewater.	The results showed a high potential for landfill leachate application. The greatest total tree biomass was achieved by P. deltoides in the balanced nutrient solution (Opt) treatment and was significantly larger compared to the other P. deltoides treatments. The highest growth rate was exhibited for all three plant species by the Opt treatment with an average of 162, 153 and 108 mm week <sup>−1</sup> for P. deltoides, S. viminalis and S. purpurea, respectively. Pot experiment limits	Sciencedirect	Slovenia
75	V.A.Tzanakakis, N.V.Paranychianakis, A.N.Angelakis, 2009	X	2009	Effects on soil, Filtration efficiency - bioremediation of effluents	<b>Case study - Experimental set up - pilot-scale systems</b>	Nutrient removal and biomass production in land treatment systems receiving domestic effluent	Each of the LTS included 16 trees planted in two double rows with four trees each. The planting distance was 1.00 m within and between double rows which separated by a corridor 3.5 m. Plots were also separated each other by a corridor 3.5 m wide. one irrigation every 2 days early in the growing season (April–May) to one irrigation daily (July–August).	municipal, domestic or household wastewater	pre-treated wastewater in a septic tank	eucalyptus, acacia and poplar	N, P, Potassium (K+) and sodium (Na+)	The climate is semi-arid with relatively humid winters and dry and warm summers. The average temperature during the winter months ranged between 11 and 13 °C and increased to approximately 17.5 and 27 °C during spring and summer months, respectively	A. cyanophylla accumulated 23, 20, and 70% more N in hypergeous biomass than E. camaldulensis, A. donax and P. nigra, respectively. A. cyanophylla and E. camaldulensis accumulated 57 and 53% respectively more P than did P. nigra and A. donax.	A. cyanophylla yielded the highest amount of biomass compared to the other species, followed by E. camaldulensis and A donax, while the lowest biomass was produced by P. nigra.	A. cyanophylla produced the greatest amount of biomass and showed the highest irrigation requirements and water use efficiency WUE, followed by E. camaldulensis, A. donax and P. nigra.	Sciencedirect	Greece



76	M.S.Al-JamalT.W.SammisJ.G.MexalG.A.PicchioniaW.H.Zachritz, 2002	X	2002	biomass production	Case study - Experimental set up - pilot-scale systems	A growth-irrigation scheduling model for wastewater use in forest production	Growth-irrigation scheduling model (GISM). Climatic inputs for the model consisted of daily maximum and minimum temperature and rainfall. an area of 1.05 ha ( m) planted with short rotation woody biomass species: Eucalyptus, Populus, and Robinia. A total of 45 test plots with an area of 0.02 ha each were planted with Eucalyptus, Populus and Robinia seedlings on m spacing.	municipal, domestic or household wastewater	wastewater	Eucalyptus	The study site climate is semiarid with an average annual rainfall of 288 mm, most of which occurs between June and October. The mean daily minimum and maximum temperatures ranged between 21 and 42 °C.		The actual biomass growth at the end of 7 months was 56% of the predicted biomass for both the low and high irrigation treatments based on the measurement of four trees. The biomass growths at the end of the third year were 86 and 74% of the model predictions for the medium and high irrigation treatments, respectively, based on the measurement of three trees. the model predicts that the dieback caused a loss of 10 kg of dry wood production over the 3 years period.	The predicted Eucalyptus tree irrigation efficiency obtained from the model at the end of the first year was only 26%, because most of the irrigation water was not used by the trees but rather lost as deep percolating water or stored in the soil profile. At the end of the second year, the predicted Eucalyptus irrigation efficiencies were between 82 and 98% for the high and low irrigation treatments, respectively. The Eucalyptus trees exhibited good height and	Sciencedirect	Mexico	
77	H.T.L.StewartP.HopmansD.W.FlinnT.J.Hillman, 1990	X	1990	Effects on soil, Filtration efficiency - bioremediation of effluents	Case study - Experimental set up - pilot-scale systems	Nutrient accumulation in trees and soil following irrigation with municipal effluent in Australia	Seven tree species were planted--river red gum. Each of the 21 plots was 20 m × 20 m, with an inner plot of 15 m × 15 m for measurements and sampling. Tree spacings were 1.5 m x 3 m (2222 stems ha-1) for the three eucalypts and river she-oak, 2 m x 3 m (1667 stems ha- ) for radiata pine, and 4 m × 4 m (620 stems ha-1) for the poplars. The fully-automated irrigation system. Irrigation was scheduled each week. During the third and fourth year of the study, around 1500 mm year- 1 (15 MI ha-1 year- 1) of irrigation was applied.	municipal, domestic or household wastewater	municipal effluent - secondary-treated municipal effluent	Eucalyptus , poplars, pines, radiata and river she oak	N, P, Potassium (K+), Phosphorus , magnesium, calciumand sodium (Na+)	Mean annual rainfall is 713 mm, with a maximum falls during winter (June-August). Mean annual pan evaporation is 1786 mm.	Accumulation of nutrients in the total biomass differed significantly between species and ranged from 34–54 g m–2 for nitrogen, 4·0–10·4 g m–2 for phosphorus, 2·1–12·2 g m–2 for sodium, 22–34 g m–2 for potassium, 12–61 g m–2 for calcium and 4·7–9·3 g m–2 for magnesium. Renovation of the effluent was therefore estimated as the amount of each nutrient accumulated in the biomass (averaged over the seven species) plus soil	Biomass production of the high-yielding species, flooded gum (Eucalyptus grandis) and Sydney blue gum (E. saligna), was around 10 kg m–2. River she-oak and river red gum (E. camaldulensis), because of their relatively large crown and litter masses, accumulated more nitrogen, phosphorus, potassium and calcium than flooded gum or Sydney blue gum. In the above-ground biomass, percentage leaf mass of the eucalypts was small (8-9%) compared with river she-oak (25%) and radiata pine (29%). Attainment of such high foliage mass at an early age resulted in a mean annual accumulation of dry matter during the 4-year period of irrigation of 20 kg m-2 year-1 or 20 tha -1year -1 (from Table 2).	Effective weed control and frequent irrigation resulted in good survival of all species (range 83–100%) at 12 months. Overall, soil chemical properties were not adversely affected by effluent irrigation over the 4-year period, though there was a trend towards more sodic conditions in the soil profile.	Sciencedirect	Australia
78	H.T.L.StewartD.W.Flinn, 1984	X	1984	biomass production	Case study - Experimental set up - pilot-scale systems	Establishment and early growth of trees irrigated with wastewater at four sites in Victoria, Australia	Irrigation was applied using either spray, sprinkler or surface systems and, at one site, was scheduled on the basis of estimated tree water use. Trees were irrigated with winery wastewater at one site and with treated municipal wastewater at the other sites.	municipal, domestic or household wastewater	winery wastewater and treated mnicipal wastewater	eucalypts, she-oaks and pine	N,P, K		Concentrations of N, P nad K in foliage of trees at Mildura 2 years after planting.	The growth of slash pine, hoop pine and yellow stringybark was extremely poor, with height increment being less than 50 cm year -1, while spotted gum had a height increment of only 1 m year -1. In contrast, swamp mahogany, river she-oak and Sydney blue gum performed well, with height increments ranging from 1.5 to 3.0 m year -1. Growth of all eucalyupts at Robinvale was reduced by Fe deficiency.			Australia

79	L.Bguo, R.E.Hsims, D.Jhorne, 2002	X	2002	biomass production	Case study - Experimental set up - pilot-scale systems	Biomass production and nutrient cycling in Eucalyptus short rotation energy forests in New Zealand.: I: biomass and nutrient accumulation	Three-month-old seedlings grown in root trainers were planted for 30 hectares in December 1993 at a density of 4167 stems/ha ( m spacing).meatworks effluent was irrigated onto the plots at a rate of 20 mm/week using flood channels between the rows of trees planted on 100 mm high ridges.	industrial wastewater	meatworks effluent stored in an anaerobic pond	Eucalyptus	N, P, K, Ca, Mg and Mn	it temperatures more in april Januay, february adn december (15-18°C). The rains is more in June, July and August (100-130 mm)	the current results were comparable with 239–639 kg/ha N accumulation in 3-year old E. botryoides and E. ovata either without irrigation or irrigated with meatworks effluent at the same site.	Eucalyptus salubris was considered the most efficient in its water use because it had the highest productivity (1169 kg ha <sup>-1</sup> year <sup>-1</sup> ) and the lowest transpiration rates. Eucalyptus torquata was only slightly less efficient than E. salubris. Eucalyptus woodwardii was comparable in terms of productivity but it transpired at much higher rates. Eucalyptus socialis and E. grossa were the least efficient in their water use because of their significantly lower productivity ( < 660 kg ha <sup>-1</sup> year <sup>-1</sup> ).	E. globulus had the highest biomass and nutrient accumulation either irrigated with effluent or without irrigation.		New Zealand
80	V.E. Tzanakakis, N.V. Paranychianakis and A.N. Angelakis, 2007	X	2007	biomass production and filtration efficiency	Case study - Experimental set up - pilot-scale systems	Performance of slow rate systems for treatment of domestic wastewater	these systems included 16 trees planted at distances of 1.00 m within and between doubled rows and systems were separated from each other by a corridor of 3.5 m. Also, rhizomes of reeds (Arundo donax) were planted at distances of 0.50 m between and within rows. Duration 3 years	municipal, domestic or household wastewater	Wastewater effluent was pre-treated in a septic tank	Acacia cyanophylla, Eucalyptus camaldulensis, Populus nigra and Arundo donax	COD, TKN, NH3-N, NO3-N, total and reactive P, TC and FC		SR systems showed great potential for COD, TKN and NH4-N removal which reached 89, 90 and 94%. An outstanding removal was also observed for TC	The fresh weights of leaves, stems and two year-old wood were recorded. The dry weight of plant biomass was assessed after repre sentative sub-samples of all plant tissues were dried at 658C to a constant weight, the present study revealed significant differences between plant species in terms of water requirement			Greece
81	M.Bhati, G.Singh, 2003	X	2003	biomass production	Case study - Experimental set up - pilot-scale systems	Growth and mineral accumulation in Eucalyptus camaldulensis seedlings irrigated with mixed industrial effluents	The present investigation was undertaken with the view that mixing of different industrial effluents. Seedlings were irrigated to maintain the soil water availability between 80% and 100% of field capacity. Height, collar diameter and number of branches were recorded at one month intervals to measure the magnitude of response to different types of industrial/municipal effluents.	municipal, domestic or household wastewater	T1: good water; T2: municipal effluent; T3: textile effluent; T4: steel effluent; T5: textile effluent+munipal effluent; T6: steel effluent+munipal effluent; T7: steel+textile +municipal effluent; and T8: steel+textile effluent	Eucalyptus	metal ions and concentrations of Ca, Mg, K, Na, N, P, TS, TSS, Cl, NH-N, NO3-N, PO4-P, Cu, Fe, Mn, Zn, K, COD, BOD, DO, SAR, TDS, EC, pH.	the Arid Forest Research Institute, Jodhpur The soil had 91.5% sand, 7.13% silt and 1.37% clay, this soil was poor in organic carbon.	Dissolved oxygen was almost absent in the steel effluent also in municipal effluent. BOD and COD were within the permissible limits except in T4, T6, T7 and T8 treatments where they were excessively high. TS, TSS and TDS were high in textile effluent, pure steel effluent and mixed effluent. Chloride was low in T1, T2, T3 and T5. The effluents in T3, T4, T6, T7 and T8 had low Ca and Mg. Metal concentrations were very low in textile effluent, but high in T4, T6, T7	municipal effluent to textile effluent improved the growth, biomass and nutritional status of E. camaldulensis seedlings. The study suggests that steel effluent was toxic to the seedlings because of high concentration of metal ions, which accumulated in soil and seedling parts. Pure textile effluent affected the root and leaf growth adversely. Seedlings irrigated with municipal effluent showed optimum growth and plant nutrient concentration. The biomass of different plant parts varied significantly among the treatments. Leaves had the highest concentration of nutrients followed by shoot and roots in all the eight treatments under study. N, P, K, Ca and Mg concentrations were high in the seedlings of T2 followed by T1 except in root in which Mg concentration was high in the seedlings of T1.	Mixing of effluents may be useful in tree irrigation to increase biomass productivity, which is evidenced by improved growth in T5 and survival in T6, T7 and T8 treatments. Further, reduction of toxic concentration of metal ions in effluents may be helpful for a long-term field application.	Sciencedirect	India
82	G.Singh, M.Bhati, 2004	X	2004	biomass production and filtration efficiency	Case study - Experimental set up - pilot-scale systems	Growth of Dalbergia sissoo in desert regions of western India using municipal effluent and the subsequent changes in soil and plant chemistry	An experiment utilizing municipal effluent in growing Dalbergia sissoo was conducted. Municipal effluent was sampled daily for 7 days at two-hour intervals (from 6 AM to 6 PM) to make a composite sample of each day. This collection provided 14 samples of municipal effluent in each season. The lysometers were filled with soil up to 185 cm, leaving 15 cm space for irrigation. Seedlings were planted in a completely randomized design with three replications, and each lysometers had one seedling.	municipal, domestic or household wastewater	Five treatments included T1, municipal effluent at 1 PET (Potential evapo-transpiration ) (without plant); T2, municipal effluent at 1/2 PET; T3, municipal effluent at 1PET; T4, municipal effluent at 2 PET; and T5, canal water at 1 PET. The pH of the municipal effluent ranged from 7.60 ± 0.01	Dalbergia sissoo	nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), copper (Cu), iron (Fe), manganese (Mn) and zinc (Zn) total solids (TS), total dissolved solids (TDS) and total suspended solids (TSS) and oxygen demand	The climate of the site is classified in the tropical monsoon type and is characterized by hot and dry summers, hot rainy seasons, warm autumns and cool winters. Summer is characterized by high temperatures and strong winds. The period from mid July to September is the monsoon season, which receives most of the rainfall. The mean annual rainfall is 420 mm and the mean annual pan evaporation is	Most concentrations of these nutrients were reduced in monsoon and increased to the greatest in summer in the municipal effluent because of high temperature and evaporation losses of water. The greatest concentrations of N, P, K, Ca, Mg, Na, Fe, Mn and Zn were detected in the leaves. The least accumulation of these minerals was in roots. Concentrations of N, P, K, Ca, Mg, Cu, Fe, Mn and Zn were greater in seedlings irrigated with municipal effluent than those	Application of municipal effluent produced better growth in D. sissoo seedlings. The concentrations were greatest in foliage compared to the other parts of seedling, with the exception of Cu concentration. Irrigation using municipal effluent did not result in toxicity to the seedlings before the age of 24 months. Addition of municipal effluent on Eucalyptus grandis has been noted to result in a doubling of growth rate when compared to E. grandis grown in a rainfed site in four years.also suggested that the seedlings supplied with near optimal amounts of water and nutrient or sewage water had greater growth rates than non-irrigated, unfertilized control seedlings of Eucalyptus globulus.	The results suggest that municipal effluent could be utilized, as an important source of water and nutrients in growing D. sissoo to increase biomass production in the needs of suburban dwellers. However, a preliminary treatment to reduce excess NH4-N and PO4-P will be required before application to the plantation. In the soil, trend suggests that continuous application of municipal effluent influenced the soil physico-chemical properties. Independent-	Sciencedirect	India



83	B. J. MYERS and R. G. BENYON, 1997	X	1997	biomass production and filtration efficiency	Case study - Experimental set up - pilot-scale systems	Environmentally Sound Management of Water and Nutrients in Australian Effluent-irrigated Plantations	Trees were planted at a spacing of 3×2 m, and the total area under plantation is 5 ha. Four treatments were applied to the experimental trials: (M) wateruse rate. (H) was irrigated at nominally 1.7 times the M rate. (L) was irrigated at nominally half the M rate. (W) gore water.	municipal, domestic or household wastewater	Secondary-treated municipal effluent was spray-irrigated through under-tree sprinklers at a nominal irrigation rate of 4.6 mm h-1.	Eucalyptus grandis and Pinus radiata	The site has a mean annual rainfall of about 570 mm which is slightly winter dominant, ranging from 63 mm in June to 37 mm in December. The mean annual temperature is 16°C, ranging from 24°C in January and February to 7°C in July. Evaporation is strongly seasonal, ranging from 319 mm in January to 36 mm in June. The site is an ex-improved pasture. Soils are a mixture of well-drained Red	At this site only 11% of the added P was taken up by the trees. Of the total P added in effluent, 98% was recovered in the top 0.7 m of soil and in the trees.	both P. radiata and E. grandis grew rapidly when irrigated with either effluent or bore water. Eucalypts grew faster during the first 3 years. However, during the 4th and 5th years, pine growth exceeded that of eucalypts and by age a 5 years their stem volume was greater and foliage mass more than double the eucalypts. The M effluent-irrigated E. grandis had a Total aboveground biomass at 4 years was 72.3 t ha-1, considerably higher than typical values available for rain-fed stands. MAI of M effluent-irrigated pines had a Total aboveground biomass at 4 years was 53.3 t ha-1. Pines were more susceptible to damage from windthrow, while eucalypts suffered more from stem de formities caused by wind breakage.	The results suggest that under-irrigation is a preferable man agement strategy from the point of view of tree stabilityand stem quality. tree death due to root pathogens occurred in 31 eucalypt trees by age 3 years, 30 of which were species in the Monocalyptus sub-genus.		Australia	
84	I.Dimitriou, H.Rosenqvist, 2011	X	2011	Filtration efficiency - economic	Economic evaluation - to calculate the economics	Sewage sludge and wastewater fertilisation of Short Rotation Coppice (SRC) for increased bioenergy productiondBiological and economic potential	The economic calculations for SRC cultivation presented in this article are based on conditions currently prevailing for SRC cultivation practices in Sweden, where an established and rather representative market exists, since c. 14,000 ha are currently cultivated for energy [13]. A method developed by Rosenqvist [14] is used for calculating gross margins.	municipal, domestic or household wastewater	wastewater	poplar and willow	n.a	Removal rates for N, P and BOD, equal to 82–93, 90–97 and 74–82%, respectively, were reported by [23] when secondary wastewater effluent (2.45 mg P/l) was applied to SRC at various rates. N retention was 90–96%, and retention of total P was c. 94%, for both willows and poplars irrigated with wastewater containing more than 300 kg N/ha yr and c. 30 kg P/ha yr.	in Sweden, the gross margin for SRC cultivation is positive only if biomass production is >9 t DM/ha yr. If all available sludge and wastewater were applied to SRC plantations, they could be grown on large agricultural areas in Europe, and c. 6000 PJ of renewable energy could be produced annually. an increase in biomass production after wastewater fertilisation can be between 20 and 50%, although higher increases could be expected in drier climates, such as in southern Europe	Application of residues to SRC has proved to be an acceptable alternative treatment method, and the farmer's profit can be markedly increased if compensation is paid for waste treatment. For a cost level of 80% and a biomass production of 12 t DM/ha yr, production costs would be lower (at 3.62 EUR/GJ) than the current price of 5 EUR/GJ, therefore a c. 30% decrease in the cost level is to be expected. this indicates the large potential of	Sciencedirect	Sweden	
85	Ioannis Dimitriou, Pär Aronsson, Martin Weih, 2006		2006	Phytoremediation	Case study - Experimental set up - pilot-scale systems	Stress tolerance of five willow clones after irrigation with different amounts of landfill leachate	The objectives of the study were to estimate stress tolerance of five different willow clones grown on pots and irrigated with landfill leachate of different concentrations. On 21 May 2002, 5-cm-long willow cuttings were planted in 1-dm3 pots filled with washed quartz sand, and with a water holding capacity of 0.2 l. In the bottom of each pot a 20-µm nytrel mesh was placed in order to prevent roots from growing outside the pots.	landfill leachate	landfill leachate	willow	N, P, K, Cl	possibly heat stress due to high summer temperatures	Higher N, lower P and higher Na concentrations in plant stems treated with leachate than control plants were observed..The N concentration in the 1:2-treatment (especially in stem) was higher than in control plants and high even compared to relevant literature (Aronsson, 2000), possibly because of the high N concentration of the leachate.	Irrigation of willows with high-ionic landfill leachate results in plant stress and reduced growth. Consequently, the results do not show at which leachate concentration plant stress becomes apparent. The clones “Jorr” and “Loden” performed best in terms of differences in relative growth rate between control and leachate treatments.	The overall pattern in the results, with large and significant differences between leachate irrigated and control plants, but small and mostly non-significant differences between the three leachate concentrations shows that landfill leachate as a plant fertilizer is clearly less suitable than a commercial liquid fertilizer.	Sciencedirect	Sweden

86	Ioannis Dimitriou, 2005	X	2005	State of the art	full-scale systems	Performance and sustainability of Short-rotation energy crops treated with municipal and industrial residues	The experiement was replicated in 5 blocks.	municipal, domestic or household wastewater	Municipal wastewaters	willow	N, P, K	N-leaching to the groundwater is a potential threat when hig N loads are applied to SRWC fields by hig wastewater irrigation rates. Comparison of experimental data from full-scale SRWC fields irrigated with wastewater in central Sweden suggests that the N load that can be treated is much higher than the N requirements of SRWC, and depends on tsite-specific conditions.				World	
87	JérGEN MORTENSEN*, KELD HAUGE NIELSEN and UFFE JéRGENSEN, 1998		1998	Filtration efficiency	Case study - Experimental set up - pilot-scale systems	Nitrate leaching during establishment of willow (Salix viminalis) on two types soil and at two fertilization levels	The experimental areas were planted with willow (Salix viminalis) early May 1993 at two sites. The willows were placed in double rows with an internal distance of 75 cm and a distance between the double rows of either 126 or 260 cm. The planting distance in the rows was 55 cm. The plot size was 12.1×13.2 m or nearly 160 m2.	landfill leachate	Nitrate leaching	willow	Mean temperature (Foulum) 12°C Mean temperature (Jydevad) 13°C The winter half years October–March 1993–94 and 1994–95 precipitation was considerably higher than normal. In the winter 1995–96 precipitation was much lower than normal.	During the following winter the nitrate concentrations decreased at both sites, but to a different extent. Even though the willow established well, only 13–16 kg N/ha accumulated in above-ground woody biomass during the first year.	The concentration of nitrogen in the wood was lower at Jydevad than at Foulum and decreased from year to year. N-fertilization had no effect on the nitrogen content in wood. The increased nitrate-N concentrations outside double rows in the unfertilised treatment at Foulum in the autumn of the first year could be caused by the shallower root development compared to inside double rows.	It is concluded that application of nitrogen should be avoided in the year of planting of willows, while in the following years75 kg N/ha can be given without risk of increased leaching.	Sciencedirect	Denmark and Germany	
88	M.Arienzo, E.W.Christen, W.Quayle, A.Kumar, 2009	X	2009	State of the art	Analysis	A review of the fate of potassium in the soil–plant system after land application of wastewaters	n.a	municipal, domestic or household wastewater	municipal and agricultural sewage effluents	Banana (M. sapientum) and Orange (Citrus aurantium)	Potassium	N.A	Tomatoes have one of the highest potassium removal rates. (reported an overall uptake of 617 kg ha–1 and a fruit removal of 170 kg ha–1.). Orange (Citrus aurantium) removes 79 kg ha–1 of K. Banana (M. sapientum) removes 774 kg ha–1 of K.	wastewater irrigation did not significantly increase potassium uptake and the plants did not manifest any symptoms of stress	Irrigation with high potassium effluent has been shown to help sustain the overall fertility in soils. In general the wastewater constitutes a fertilizing mineral and organic matter potential and hence the potassium in wastewater can behave differently to fertilizer potassium.	Sciencedirect	Australia
89	I. Dimitriou and P. Aronsson, 2005	X	2005	Phytoremediation	Analysis	Willows for energy and phytoremediation in Sweden	The willows are irrigated for about 120 days annually. an adjacent 75-ha willow plantation during the growing season. Irrigation ceases automatically on rainy days.	municipal, domestic or household wastewater	Urban wastewater	willow	N	It was assumed that if biomass production were 10 tonnes of dry matter per hectare and then 50 kg of nitrogen per hec tare would be removed from the field at harvest each year.	In 2005, biomass production of wil low grown commercially in Sweden is about 6 to 12 tonnes per hectare per year, depending strongly on site conditions. When used for phytoremediation, short rotation willow coppice offers advantages such as high biomass yields and removal of hazardous compounds and nutrients through frequent	About 16 000 ha of willows in short rotation coppice systems are currently grown in Sweden, consisting mainly of different clones and hybrids of Salix viminalis, S. dasyclados and S.		Sweden	



90	L.Bguo, R.E.H sims, 2001	X	2001	Filtration efficiency	Case study - Experimental set up - pilot-scale systems	Eucalypt litter decomposition and nutrient release under a short rotation forest regime and effluent irrigation treatments in New Zealand: I. External effects	The stands used in this study were 1- to 3-year-old E. globulus with a tree density of 4167 stems ha <sup>-1</sup> (1 m spaces×2.4 m rows). Tree seedlings were planted annually in three 30 ha blocks over a 3-year period in November 1992, 1993 and 1994.	industrial wastewater	Meatworks effluent	Eucapyyt	nitrogen, phosphorus, potassium, calcium, magnesium and manganese	Temperature was between 10-18 °C and rainfall 60-130 mm. Between december to march the temperature was higher.	Effluent irrigation increased: the nitrogen release from 26 to 48% and after until 47%. nitrogen accumulation in litter was 50%. phosphorus release was from 2 to 32% under 1-year-old stands, but had little effect under 2-year-old stands, where litter accumulated 63% more. Effluent irrigation resulted in magnesium net accumulation under 3-year-old stands, but retarded its release. Effluent irrigation enhanced the calcium release under 1-year-old	Phosphorus, magnesium, and nitrogen accumulated more than their initial amount in the litter, particularly under 3-year-old stands irrigated with effluent. Effluent irrigation significantly increased litter dry weight loss from 46 to 75%.	In the current study, net nutrient accumulation was found for phosphorus, magnesium, and nitrogen, but not for potassium, calcium and manganese		New Zealand
91	T.G.Baker, W.J.Dyck, P.G.Barton, G.R.Oliver, G.Nicholson. 1990	X	1990	Filtration efficiency	Case study - Experimental set up - pilot-scale systems	Effect of irrigation with sewage effluent on decomposition of litter in Pinus radiata forests	Two Pinus radiata D. Don forests (aged 18 and 25 years) were spray-irrigated for 32 months with domestic sewage effluent from a secondary oxidation pond. Effluent was applied at rates of 25 and 50 mm week <sup>-1</sup> . Three 0.019-ha plots were established in P. radiata on the silt loam soil: a control, and 2 irrigated plots receiving 25 and 50 mm week <sup>-1</sup> of effluent respectively. A 0.10-ha control and an irrigated plot ( 25 mm week <sup>-1</sup> ) were established in P. radiata (planted 1963, present stocking 630 trees ha <sup>-1</sup> ) on the clay soil	municipal, domestic or household wastewater	domestic sewage effluent	Pinus radiata	N, P, K, Ca and Mg	two contrasting soils: (1) Red Loam soil complex and (2) Northern Yellow Brown Earth. Mean annual rainfall during the study was 1400 mm and mean summer and winter temperatures were 19°C and 12°C respectively.	Irrigation increased the pH and the availability of P, Ca and Mg in the soil. Concentrations of P and Ca in litter increased markedly as a result of irrigation, but those of N, K and Mg were variably affected between soils. There was no effect of irrigation on concentrations of organic C and total N, or bulk density. Increases of the concentrations of N, P, Ca and Mg in the litter residue due to irrigation were closely associated with increased rates of	Irrigation decreased litter organic matter by 43%–57% but there was no change in organic matter in the soil. 32 months of irrigation with sewage effluent significantly reduced the amounts of organic matter in the litter layers on both silt loam and clay soils, but did not affect the amount of organic matter in the 0-50-mm soil layer.	The effect of irrigation on decomposition rates was due, in part, to the maintenance throughout the year of a more suitable environment in the litter for decomposers, particularly during dry summer periods.		New Zealand
92	Jill A.Zalesny, Ronald S.ZalesnyJr., David R.Coyle, Richard B.Hall, 2007		2007	Phytoremediation	Case study - Experimental set up - pilot-scale systems	Growth and biomass of Populus irrigated with landfill leachate	Our objective was to irrigate Populus trees with municipal solid waste landfill leachate or fertilized well water (control) (N, P, K) during the 2005 and 2006 growing seasons and test for differences in tree height, diameter, volume, and biomass of leaves, stems, branches, and roots.	landfill leachate	landfill leachate	Poplar	N, P, K	Temperature was between 5-20°C and precipitaion 3,9-17,14 cm.	depending on the contaminants, phytoremediation plantations may be harvested in 8–10 years for fiber or energy, utilizing short rotation forestry to offset demand and conserve natural forest stands.	The total aboveground biomass ranged from 0.51 to 2.50 Mg ha <sup>-1</sup> , with a mean of 1.57 Mg ha <sup>-1</sup> . Overall, the mean total tree dry mass was 529.6 ± 189.2 g. In their study, 35–81% of aboveground biomass was comprised of stems, while 19–65% was in the leaves. it prevents the unwanted leaching of potentially harmful contaminants into nearby watersheds.	there is a great potential for remediation of landfill leachate using Populus. Overall, given that every leachate source should be regarded as unique, there is an essential need for initial genotype screening followed by the establishment and evaluation of test plots to ascertain clonal performance prior to large-scale deployment.		

93	V. O. Snow, C. J. Smith, P. J. Polglase, and M. E. Probert, 1999	X	1999		Modeling	Case study - Experimental set up - pilot-scale systems	Nitrogen dynamics in a eucalypt plantation irrigated with sewage effluent or bore water	Nitrogen transformations and leaching from E. grandis irrigated with effluent or bore water was modelled successfully using APSIM. Decomposition of dead weeds and leaf litter, using the module RESIDUE. Net mineralisation, nitrification, and denitrification were modelled using SOILN.	municipal, domestic or household wastewater	Treated effluent	Eucalyptu	N		the predicted nitrogen balance of the effluent-irrigated treatment showed that the accumulation of nitrogen in the aboveground biomass and litter (335 and 19 kg/ha) was significantly less than the amount of nitrogen added in effluent (508 kg/ha). Denitrification at this site was low, about 52 kg/ha over 5 years. After 5 years, organic nitrogen decreased by 167 kg N/ha, and 269 kg N/ha was leached.	only about 340 kg N/ha was recovered in the aboveground biomass. the amount of nitrogen returned in leaf fall was about 90 kg N/ha.year. Each year, approximately 50 kg N/ha accumulated in the wood of the effluent-irrigated trees and slightly less in the trees irrigated with bore water.		ResearchGate	Australia
94	W stephens, S.Ftyrrel, J.-E Tiberghien. 2000		2000	biomass production and filtration efficiency		Case study - Experimental set up - pilot-scale systems	Irrigating short rotation coppice with landfill leachate: constraints to productivity due to chloride	14 Salix clones were planted in 1-dm3 pots with pure sand. 35 plants were then transplanted into pots (25 cm diameter × 27 cm depth)	landfill leachate	landfill leachate	willow	chloride	Rainfall was recorded at the Silsoe met station some 300 m away from the experimental site.	The chloride rapidly affected the appearance and growth of the trees. After one day, trees irrigated with >200 mmol l <sup>-1</sup> showed visual signs of water stress with less erect, dark green-blue foliage. all of the trees subjected to 422 mmol l <sup>-1</sup> chloride had died. Sustainable growth and development of willow is unlikely at chloride concentrations greater than 70 mmol l <sup>-1</sup> .	Willow selection and breeding traditionally have focused on high biomass production under optimum environmental conditions.		Sciencedirect	UK
95	I.Dimitriou, P.Aronsson, 2010		2010	Filtration efficiency		Case study - Experimental set up - pilot-scale systems	Landfill leachate treatment with willows and poplars – Efficiency and plant response	The lysimeters (12 in total) consisted of cylindrical fibreglass containers with a cross-sectional area of 1.0 m2 filled with soil. The drainage water from each lysimeter was collected in 25-L polyethylene bottles placed at the underground collection point, where the temperature varied from 5 to 8 °C.	landfill leachate	landfill leachate	willow and poplar	N, P, and TOC	The mean annual temperature at the site is 5.5 °C and mean precipitation is 527 mm/yr.	Ability to retain total N and P, and TOC was relatively high for willow, taking into account the large amounts supplied, and better than for poplar. the retention of total N for the treatment (corresponding to supply of 126 kg N/ha yr) was high (93.8%). Retentions of P and TOC for the treatment (corresponding to a supply of 6.7 kg P/ha and 707 kg TOC/ha, respectively) were 99.8% and 92.5%, respectively.	Leachate irrigation increased willow biomass production, but not that of poplar.		Sciencedirect	Sweden
96	Ronald S.ZalesnyJr. Adam H.Wiese, Edmund O.Bauer, Donald E.Riemenschneider 2009		2009	biomass production		Case study - Experimental set up - pilot-scale systems	Ex situ growth and biomass of Populus bioenergy crops irrigated and fertilized with landfill leachate	The trees were arranged in a split-split plot, repeated measures design, with two blocks, two treatments, six clones, and four sampling dates. Clones were	landfill leachate	landfill leachate	Poplar		The trees were grown in a greenhouse at the Institute for Applied		The overarching practical implication of our results was that specific clones of Populus exhibited great establishment potential (i.e. elevated growth and		Sciencedirect	USA



97	Ronald S. Zalesny Jr. and Edmund O. Bauer, 2007		2007		Case study - Experimental set up - pilot-scale systems	Phytoremediation	SELECTING AND UTILIZING POPULUS AND SALIX FOR LANDFILL COVERS: IMPLICATIONS FOR LEACHATE IRRIGATION	Identify Objectives, Biological Processes of Remediation, and Plant Traits of Interest Identify and Select Favorable Clones from Phyto-recurrent Selection Cycles TREE ESTABLISHMENT IN THE FIELD EVALUATING METRICS OF SUCCESS	landfill leachate	Landfill leachate	willow and poplar		it may be possible to increase phytoremediation success with proper genotypic screening and selection, followed by the field establishment of clones that exhibited favorable potential for clean up of specific contaminants.	Populus whips up to about 3 m in length also have been used for phytoremediation systems, where there was a need to plant deep so that the tree roots intercept a soluble subsurface plume, to achieve greater biomass more rapidly, or to gain height quickly in periodically-flooded areas. Researchers have reported successful tree growth and remediation potential when these genera have been irrigated with landfill leachate.	we detail phyto-recurrent selection, a method that consists of revising and combining crop and tree improvement protocols to meet the objective of utilizing superior Populus and Salix clones for remediation applications. Objectives vary with site characteristics, contaminant properties, and choice of plant species. Populus and Salix genotypes have greater potential for positive responses to landfill leachate irrigation than most clones that		
98	ERICS.FABIO and LAWRENCE B. SMART	X	2018		Analysis	State of the art	Effects of nitrogen fertilization in shrub willow short rotation coppice production – a quantitative review	This review is intended to provide a quantitative examination of the effect of fertilization treatments on willow biomass yield in field conditions. Data from the literature were collected and summarized to test for significant sources of variation in willow biomass nitrogen (N) pools of common SRC genotypes used in North American and European research programs. A literature search was conducted using ISI Web ofScience and Google Scholar databases.	municipal, domestic or household wastewater		willow			Overall, this quantitative review has shown that fertilization of willow can substantially improve yields, with an overall increase in yields of 40% over control treatments. Important factors have been identified that can influence yield response, including willow species or species hybrids, fertilizer source, the age of above-ground biomass at harvest, growing climate, and the unfertilized yield potential of a particular location.		ResearchGate	EU
99	M.N. Hashim, O. Abd Razak, K. Rosdi and M.K. Soliman	X	2010	Bioremediation	Case study - Experimental set up - pilot-scale systems		Wastewater-irrigated industrial woody plantations for rehabilitation of arid areas in Egypt	In this paper we describe the efforts to rehabilitate arid areas in Egypt using wastewater as source of irrigation. Both short- and long-rotation trees such as Sesbania, Casuarina, Eucalypt, Khaya and Jatropha have been tried and successfully established in desert and marginal areas. the total forest plantation area in Egypt was 52 000 ha in 1990. Annual planting during the period 1991–2000 was 2000 ha per year increasing at the rate of 3.3%. The total area of forest plantations in the year 2000 was about 71 200 ha. All plants are planted on 3 m × 3 m spacing and drip irrigated with tertiary or secondary treated wastewater (90 000 m3 per day).	municipal, domestic or household wastewater	urban sewage tertiary or secondary treated wastewater	Casuarina glauca, Eucalyptus camaldulensis and Tamarix aphylla	The context is marked by limited water resources (Falkenmark indicator nearly 650 m3 / year / inhabitant) and high water needs for agriculture. sandy soils in areas such as Al Gabal Al Asfar and Abou Rawash. 95% of Egypt is non-cultivable and consists of deserts and marginal areas.	Since the 1990s, Egypt has decided to recycle TMEs for watering planted forests (Figure 21). Pilot plantations of high forest were made in 10 governorates covering all agricultural climatic zones. Egypt is one of the first countries to have developed public-private partnerships on REUT for these projects. REUT was therefore carried out on forest plantations in the desert, but never to irrigate other crops such as market gardening and field crops.	ResearchGate	Egypt		
100	M.S.Omran, T.M.Waly, E.M.Abd Elnaim, B.M.B.El Nashar, 1988	X	1988	Filtration efficiency	Case study - Experimental set up - pilot-scale systems		Effect of sewage irrigation on yield, tree components and heavy metals accumulation in navel orange trees	Five soil sites irrigated with sewage water for 10, 20, 30, 40 and 60 years were chosen to study the effect of this irrigation on orange trees. Four orange trees for each of the sites were selected as being as uniform as possible.	municipal, domestic or household wastewater	sewage water	orange trees	Fe, Zn, Mn, Cu, Ni, Pb, Cd, Co	Juice contained the lowest concentration of all the heavy metals investigated, but concentrations tended to increase with prolonged sewage application. Contents of heavy metals were as follows: Fe>Zn>Mn>Cu>Ni>Pb>Cd>Co in leaves and peels and Cu>Mn>Zn>Fe>Ni>Cd>Pb>Co in juice.	The longer the time of sewage application to the orange trees the greater the vegetative growth, fruit yield and heavy metals content. However, the concentration of heavy metals in fruit juice was within the permissible limits and below the level toxic to man or plants.	r	Sciencedirect	Egypt

101	Saida Bedbabis, Giuseppe Ferrara, Béchir Ben Rouina, MakkiBoukhris, 2010	X	2010	Filtration efficiency		Effects of irrigation with treated wastewater on olive tree growth, yield and leaf mineral elements at short term	Two experimental plots were considered: one plot irrigated with well water (WW) and the other irrigated with treated wastewater (TWW). Each experimental plot consisted of nine Chenlali olive trees, spaced 24 m × 24 m, irrigated either with TWW or WW, with a drip irrigation system with four drip nozzles (two per side) set in a line along the rows (at 0.5 m from the trunk). Trees were irrigated for about 60 days in the period April–October.	municipal, domestic or household wastewater	treated wastewater	olive tree	nitrogen (Nt), potassium (K), phosphorous (P), and heavy metals (i.e. Zn, Mn, Pb and Cd	Beside rainfall, the daily water supply per mature olive tree was 4.5 m3, in total 5000 m3 ha–1 year–1. In arid regions, such as Tunisia. Temperature (12-30°C) and rainfall max. >120 mm, the rainiest months June, July and August.	After two years, non-significant injuries caused by salts and/or heavy metals were observed on shoot growth of trees irrigated with TWW. The application of TWW significantly increased concentration of Nt, P and K in the leaves, whereas heavy metals (Zn and Mn) showed a significant increase only after the second year of irrigation.	In the low yield period (2003), olives production was 86.4 kg tree–1 in TWW treatment compared with 27.6 kg tree–1 in WW treatment. In conclusion, our data showed that irrigation with TWW caused a limited vegetative growth retardation but a highly significant increase of the yield in both years. TWW worked as fertirrigation supplying N, P and K in large amounts. Finally, the application of TWW caused an increase of Mn and Zn in soil and leaves but within the usual range detected in plants.		Tunisia	
102	K.M.Al-Absi, F.M.Al-Nasir, A.Y.Mahadeen, 2009	X	2009		Case study - Experimental set up - pilot-scale systems	Mineral content of three olive cultivars irrigated with treated industrial wastewater	This investigation was carried out in two locations. The first (pot) experiment was carried out at a partially controlled glasshouse, in which temperature and ventilation, can be controlled, while the second (field) experiment was carried out at the olive orchard of Al-Hussein Bin Abdullah II Industrial Estate (HUIE), during the period March 2004 to January 2006.	municipal, domestic or household wastewater	saline treated industrial wastewater generated by textile firms mixed with municipal domestic effluent	olive	Ca, Mn, Zn, Cu, Fe, Pb and Ni	controlled glasshouse, in which temperature and ventilation, can be controlled	In general, levels of Ca, Mn, Zn, Cu, Fe, Pb and Ni were below the recommended maximum concentrations and within the guidelines for irrigation of agricultural crops. The analysis shows that it contains low amount of N, P and K which are considered essential nutrients for plant growth and development. However, impermissible accumulations of Na and Mg, slightly higher than the recommended maximum concentrations, were observed, 33 and 40.3% higher than the recommended maximum limits.	Generally, the plants of all cultivars grown under greenhouse conditions manifested no noticeable injury symptoms when irrigated with effluent at all concentrations, except 'Improved Nabali' that showed slight symptoms of dead leaf edges at the effluent with the highest EC of 5.0 dS m–1 14 months after starting the experiment.	The results show that treated wastewater can be used to irrigate olives as a source of water and fertilizer with a continuous monitoring of the effluent quality and the toxic levels of Cu, Fe and Na in leaves in order to correct the toxic and deficient concentrations.	Sciencedirect	Jordan
103	Laila Mandi, Naaila Ouazzani, 2013	X	2013	Filtration efficiency	full-scale systems	Water and wastewater management in Morocco: Biotechnologies application	About more than 70% of the treated water coming from this WWTP are re-used recreational purposes (golf course, palm grove, etc.). In this plant, about 120,000 m³/d of wastewater are treated in four stages: 1) pre-treatment 2) primary treatment in sedimentation tank 3) secondary treatment that employs activated sludge (i.e. aerobic sludge treatment) 4) tertiary treatment, which consists of microfiltration by sand filter and disinfection by ultraviolet lamp units. Most of the wastewater produced by inland towns is reused, mainly as raw or insufficiently treated wastewater, to irrigate about 7500 hectares.	municipal, domestic or household wastewater	urban and industrial wastewater treated	palm grove		Morocco is situated in arid area and has been faced to several water management problems. In addition of the aridity of climate, the heterogeneity of water resources distribution, repetition of drought related to climate change reduce the potential of water resources.	Reduce pollution caused by wastewater at least 60%.	The treatment and re-use of Marrakech's wastewater is a milestone in sustainable development, which made significant progress towards attaining Morocco's national target of 60% effluent treatment by 2020.		Morocco	
104	Universita Degli Studi della Tuscia, DIBAF, 2012	X	2012	Biomass	Case study - Experimental set up - pilot-scale systems	Treated waste water for sustainable production of valuable biomass, soil and water quality improvement and combating desertification in Algeria and Tunisia	Drip irrigaiton installation.	municipal, domestic or household wastewater	treated waste water	Tamix, acacia				photo logbook		Algeria y Tunisia	
105	FAO. S. Braatz et A. Kandiah, 1996	X	1996	biomass production and filtration efficiency	Analysis	Recyclage des eaux usées urbaines pour l'irrigation des forêts et des arbres - Urban wastewater recycling for irrigation of forests and trees	In designing a system, much attention should be paid to site characteristics, rates of water use, adaptation of water distribution and application methods, selection species and commercial outlets.	municipal, domestic or household wastewater	Urban wastewater	An experimental eucalyptus (background) and poplar (foreground) plantation				Appropriate irrigation techniques and water quality standards for tree irrigation need to be developed.		Kuwait	



106	Mauro Viccaro, OrcID,Mario Cozzi,Donatella Caniani,Salvatore Masi 2,Ignazio M. Mancini 2,Marianna Caivano 2 andSeverino Romano	X		biomass production and filtration efficiency	Economic evaluation - to calculate the economics	Wastewater Reuse: An Economic Perspective to Identify Suitable Areas for Poplar Vegetation Filter Systems for Energy Production	In this study, a geographic information system (GIS)-based spatial model was developed to identify areas potentially suitable for creating vegetation filter systems with poplars to size the plants of energy production. An economic assessment allowed us to identify the cost-effectiveness areas for biomass production that can be fertigated by reclaimed wastewater. Considering the Basilicata region as the test region, a surface area of 258,512 ha was investigated, identifying 73,331 ha of SRF soils sited downstream of 45 wastewater treatment plants (WWTPs).	municipal, domestic or household wastewater	Wastewater	poplar		Basilicata region	The findings of the Basilicata region show that the use of treated municipal wastewater is economically advantageous to cultivate up to 1606 ha of SRF of poplars, contributing to achieve the objectives of the NAP with 50 MW for thermal, 8 MW for electrical, and up to 31 MW for cogeneration plants. In addition, the alternative treatment of wastewater through vegetation filter systems results in an economic advantage for the companies in charge of water treatment. A study conducted in Ireland has demonstrated that this compensation for farmers may amount to 788–2004 GBP/ha year	Finally, the present study proves that the increase in yields due to fertigation with wastewater represents not only an economic advantage but also an increase in energy efficiency.		Italy	
107	Murillo JM, Lopez R, Fernandez JE, Cabrera F (2000)	X	2000	biomass production and filtration efficiency	Case study - Experimental set up - pilot-scale systems	Olive tree response to irrigation with wastewater from the table olive industry	A field experiment was conducted to examine the effect of drip irrigation. Two types of wastewater were used in the experiment and other of control. In a large plastic container with a capacity of 12,000 l. , which are replenished twice a week. The trees are at a spacing of 4 x 6 m. Water an effluents were supplied daily from 10 July to 11 September, by a single lateral drip line placed on the soil surface in each tree row.	industrial wastewater	wastewater from a table olive industry	olive	N, P, K, Ca, Mg, Na, Mn, Zn, Cu and B	Some days were typically hot, dry 34,5 °C and humidity was 27%.	This treatment also caused a rapid, significant reduction in leaf N concentration, compared with the N level in the trees before irrigation. N, P and B had the less concentration, the others exceed the limits.This type of wastewater seems to be totally unsuitable for agricultural purposes, mainly due to its highly variable composition and salt content, with SAR values often being extremely high.	Olive trees rapidly responded to wastewater application. Compared to the control (fresh water), the ore saline wastewater caused important decreases in leaf water potential, stomatal conductance to HO and the photosynthesis rate after only 15 days of irrigation, the reduction being more pronounced after 2 months of irrigation.	These results indicate that this kind of eastewater is unsuitable for application to olive orchards under irrigation.		Spain
108	Klaus Sieg, 2019	X	2019	biomass production and filtration efficiency	full-scale systems	Greening the Desert With Wastewater	The water comes from the nearby city of Ismailia, population 400,000. On this 200-hectare site on the west bank of the Suez Canal, timber is growing in the scorching heat of the desert. The Serapium Forest is part of a project launched by the Egyptian government more than 25 years ago. These state forests in the desert are irrigated using pre-treated sewage effluent.	municipal, domestic or household wastewater	pre-treated sewage effluent	eucalyptus		Trees are a rarity in Egypt. Ninety-six percent of the country is desert, and the parts that are not are either farmed intensively or populated densely, usually along the banks of the Nile.	And not just growing, but growing fast. There is a big market for timber in Egypt and neighbouring countries. The fast-growing trees are ready to harvest in just 11 to 15 years, and they yield an average of 350 cubic metres of timber per hectare. Almost 30 different types of trees have been growing on a ten-hectare site in the Serapium Forest.	Corruption was and is widespread. The economic situation is catastrophic. These conditions have left Serapium Forest in a precarious position.		India	
109	Darja Isteni'c, Gregor Boži'c, 2021	X	2021	biomass production and filtration efficiency	Case study - Experimental set up - pilot-scale systems	Short-Rotation Willows as a Wastewater Treatment Plant: Biomass Production and the Fate of Macronutrients and Metals	The study was conducted on a 27 m2 pilot EWS built next to a municipal WWTP in Ajdovš'cina, Slovenia. Briefly, the pilot EWS consisted of nine watertight treatment beds (each 3 m long, 1 m wide), filled with local soil (1.5 m deep) and planted with three clones of S. alba at a density of 1 tree per m2. Each clone was tested in three parallel beds distributed in a Latin square to minimize environmental differences caused by positioning (north/south orientation, prevailing wind direction, etc.). In addition, control trees were planted around the EWS to avoid the edge effect and to be monitored as control plants.	municipal, domestic or household wastewater	treated wastewater	willow	BOD5, TP, PO4P, COD, NH4-N, NO2-N and NO3-N	Despite the high annual precipitation (1330 mm), uneven distribution of rainfall, high average annual temperatures (13.5 °C), high solar radiation and strong winds caused high evapotranspiration (reference ET0 975 mm) and lower water availability for control willows, resulting in lower biomass production	'V 052' (S. alba L. var. calva G.F.W. Mey x S. alba L.) the highest nitrogen and phosphorus uptake (48% and 45%). The uptake of N and P from wastewater into harvestable wood biomass was significant compared to other plant-based wastewater treatment systems, indicating a good nutrient recovery potential of EWS. Wastewater composition and loading were consistent with willow nutrient requirements; however, the uptake of macronutrients and metals may be hindered or altered by increasing salinity. In this study, K2O levels were slightly elevated in the soil of the EWS.	The annual biomass production (17–19 and 17–30 t DM ha–1 y –1 , for willows aged 2/3 and 2/5, respectively). The study showed that S. alba clones were suitable for use in EWS and produced significantly more biomass when irrigated with wastewater. 'V 052' was the highest, produced the highest number of shoots and had the highest biomass yield (38–59 t DM ha–1 ) in both rotations.	EWS are now used in rural areas in all Scandinavian countries, the Baltic States, Poland, England, Ireland, and China and there are pilot studies in Slovenia, France and Greece. Increased salinity has been noted as increased Na concentration in the soil and woodybiomass, and decreased Ca and K uptake after only two years of operation; however, the plants in Denmark have been in full operation for 20 years, and to our knowledge there have been no reports of decreased willow growth, evapotranspiration, or other deleterious effects that may be caused by increased salinity, indicating		Slovenia

110	Carlos A Arias, Hans Brix, 2011	X	2011	biomass production and filtration efficiency	Analysis	Use of willows in evapotranspirative systems for onsite wastewater management ? theory and experiences from Denmark	In Denmark more than 500 ET systems planted with willows are in operation. The systems generally consist of a 1.5 m deep high-density polyethylene-lined basin filled with soil and planted with clones of willow ( <i>Salix viminalis</i> L.). Settled sewage is dispersed underground into the bed under pressure. The beds are built up in the original soil from the site. A 0.3 m high dike is built up around the bed to avoid water from the surroundings to enter the willow bed, and to allow water to accumulate on the surface during the winter. Because of the availability of membranes, a standard system will have a width of 8 m, a depth of 1.5 m, and its length will depend on the needed area. It is an advantage to establish deeper beds, with more vertical slopes on the sides. Harvesting generally takes place on a 2 or 3-year cycle.	municipal, domestic or household wastewater		willow		Willow systems that are not contained in a membrane-enclosed bed allow some soil infiltration (Ministry of Environment and Energy, 2003b). The system with infiltration is intended to be used on clayish soils, where infiltration is low. But usually sewage from single households contains low levels of heavy metals.	Willows must be either planted immediately or stored at -2 to -4°C, where cuttings will remain viable for several weeks. Willows should be planted in rows about 1 m apart and with approximately 1.5 m between each set of three rows. The spacing along the rows should be 0.4-0.5 m. From each cutting, 1–3 shoots will arise and reach up to 4 m in height by the end of the first growing season. To minimise the risk of pest damage, three different varieties of willows are planted in alternate rows. With 'normal' contents in 'normal' household wastewater, i.e. 30 mg/L total-N, 10 mg/L total-P (Henze, 1982), and 30 mg/L K, the amount of N, P and K in the harvestable biomass almost exactly balances the amount discharged into the system with the sewage. Only for P, the amount discharged into the system was about 30% higher than the amount in the harvestable biomass. The balance for P will however depend on the use of phosphate-containing detergents in the specific household.	The United Nations through the agency FAO has developed software called CROPWAT as a tool to calculate reference evapotranspiration, crop water requirements, and crop irrigation requirements. The software is available for free from the internet and can be found and downloaded at the address <a href="http://www.fao.org/ag/AGL/aglw/cropwat.stm">http://www.fao.org/ag/AGL/aglw/cropwat.stm</a> .		Denmark
111	L.Bguo, R.E.Hsims	X	2000	biomass production	Case study - Experimental set up - pilot-scale systems	Effect of meatworks effluent irrigation on soil, tree biomass production and nutrient uptake in Eucalyptus globulus seedlings in growth cabinets	The effects were examined of five different irrigation rates of water or meatworks effluent on the soil, tree biomass production and nutrient uptake of Eucalyptus globulus seedlings grown in three growth cabinets at various temperatures (5°C, 15°C and 25°C), representing seasons (winter, spring/autumn and summer). The experiment was conducted for a 13 week period in 1996, New Zealand. Three factors were investigated to assess their effects on soil properties, tree growth and tree nutrient uptake	industrial wastewater	meatworks effluent	Eucalyptus	Temperature: 2.5°C in the dark, 7.5°C in the light; 12.5°C in the dark, 17.5°C in the light; and 22.5°C in the dark, 27.5°C in the light. (These three temperature regimes represented winter, spring or autumn, and summer in the field. For ease of reporting they have been termed “5°C”, “15°C” and “25°C”, respectively.)	How much of the nutrients originating from the effluent were recovered by the seedlings was not dependent on nutrient input via effluent irrigation, but highly dependent on the temperature. The most successful nutrient recovery occurred at 15°C, but with more nitrogen recovered (average about 60%) than phosphorus (average about 30%). At the same time, it enhanced tree leaf area, biomass production, nutrient uptake and shoot: root ratio. At 5°C, the highest nitrogen accumulation (84 mg/tree) and phosphorus accumulation (9.0 mg/tree) were found in seedlings with 20	Effluent irrigation enhanced tree leaf area, biomass production, nutrient uptake and shoot:root ratio. At 5°C, the highest dry weight (5.5 od g/tree) occurred in the seedlings receiving 20 mm/week effluent irrigation. There was only a little difference between all other treatments, even those without any irrigation. There was no significant difference in the shoot:root dry weight ratios at 5°C, but at 15°C, the ratios were higher in the seedlings irrigated with effluent than in those irrigated with water. In this pot trial, less than 25% of the total biomass was in the root system. The greater the effluent irrigation rate, the more the leaf area. In this pot trial, about 50% of biomass, 60% of nitrogen, and 50% of phosphorus were found in the leaves of the seedlings.	ence, all these factors should be considered when managing forest systems linked with effluent land-treatment systems. Meatworks effluent can be successfully treated by irrigating fast growing tree species, such as E. globulus.		New Zealand
112	Asha Pandey, Mohini Singh, R K Srivastava and Padma Vasudevan	X	2011	biomass production and filtration efficiency	Case study - Experimental set up - pilot-scale systems	Pollutant removal potential, growth and nutritional characteristics of short rotation woody crops in grey water vegetation filter system	This study evaluaes use of vegetation filter for pollutant load removal from grey water GW, generated from GBPUAT, India. Grey water is rich in nutrients and organic load and was used for fertigation of woody crops of Eucalyptus hibrid, Populus deltoides, Salix alba and Melia azedarach. Two equal plots (50m x 40m each) were selected for treatment and control field trials, leaving a buffer zone of 20 cm between two plots. These tree species were planted at a dintace of 2 m x 2 m on both sides of channel bunds used for irrigation GW and CW. Both plots received equal quantity of water (400 m3 per week in two instalments of 200 m3 each).	municipal, domestic or household wastewater	grey water	eucalyptus, poplar, salix and melia		Average reduction of N, P and K was 50, 34 and 15%, respectively. Reduction in BOD and COB were 60% and 46% respectively with residual BOD < 0 mgl. Annual average BOD removal (48%) reduced from 56 mg/l at I to 29 mg/l at O of vegetation filter. BOD reduction was highest (60%, from 54 at 21.4 mg/l) in October. Annual average removal of COD in GW (46%) was 214 mg/l at I and reduced to 115 mg/l at O, its highest was in October. Annual average reduction in concentration of nutrients were as follows: N 51% (from 35 to 17 mg/l), P 34% (from 8.5 to 5.7 mg/l), and K 15%	Dry biomass yield of woody crops under wastewater irrigation in comparison to control ground water was: Eucalyptus hybrid 143, P. deltoides 54, S. alba 274, and M. azedarach 321%. Nutitive value of M. azedarach leaves as a fodder was found good. All selected plant species registrered better growth with GW irrigation without showing any visual symptoms of stress and disease. Total dry biomass production for species increased (54-321%) in GW irrigated plot in comparison to CW irrigation in 1 yr. TABLE 1	This study found fertiligation with wastewater enhanced biomass production simultaneously achieving pollution removal by land treatment system with vegetaion filter.		India



113	M Edraki, H.B So, E.A Gardner	X	2004		Case study - Experimental set up - pilot-scale systems	Water balance of Swamp Mahogany and Rhodesgrass irrigated with treated sewage effluent	biomass production	The tree plots designated as T10, T20, T30 and T40 received four different nitrogen (N) concentrations of 10, 20, 30 and 40 mg/l, respectively. The objective of the study was to compare growth and water use of these plantations and the possible effluent losses to the environment. Ten plots of 24 x 36 m each.	municipal, domestic or household wastewater	wastewater	Swamp Mahogany (Eucalyptus robusta Sm.) and Rhodes grass (Chloris gayana Kunth var. Callide)	Monthly rainfall was generally lower than that of the long-term mean of the region, except for a very wet period in May 1996 when a major flood with a frequency of 1 in 20 years occurred in the area (Wedding, 2003, personal communication) and 700 mm rainfall was recorded over a 10 day period.	Annual ET was measured to be 982 and 1126 in the first year and 1192 and 1269 mm in the second year by grass and T30 trees, respectively. Comparison of the slopes for individual treatments (Fig. 3) indicated the highest N treatment (T40) was significantly different from T10 and T20 treatments.	The highest interception losses (10%) were in plot 10 (T40) with the Leaf area index LAI varying from 1.2, 2.5 and 3.5 for the same periods. The measured saturated hydraulic conductivity decreased with depth. A sharp decrease in the rate of infiltration occurred, 43 h after the start of the experiment by the time the whole surface soil became saturated followed by reduced flow into the clay subsoil. Evaporative losses from trees and grass in this study followed by interception comprised the largest portion (77% in the second year) of the water balance. Only the highest N treatment plots (T40) were transpiring at rates significantly greater than the grass plot (G30).	Wastewater application and subsurface drainage in the FILTER system can be regulated to ensure adequate removal of pollutants, thereby producing minimum-pollutant drainage water, which meets general environmental criteria for discharge to surface water bodies throughout the year. The specific design and operation of the FILTER system at a given site needs to take into account site features such as soil and hydrological conditions, rainfall, and potential evapotranspiration rates.		USA
114	Muhammad Ayyoub Tanvir* and Muhammad Tahir Siddiqui	X	2010	biomass production	Case study - Experimental set up - pilot-scale systems	Growth performance and cadmium (Cd) uptake by Populus deltoides as irrigated by urban wastewater		Present research experiment was laid out in randomized complete block design (RCBD) with three treatments. Total number of plants (P. deltoides) used in whole of the experiment were = 6 x 3 x 3 = 54. Oneyear- old seedling of almost uniform size were planted in spring 2006 at an equal spacing of 2m x 2m from plant to plant and row to row with the stocking rate of 2500 trees per hectare. All experimental plots were irrigated uniformly by flood irrigation system. Irrigation was applied at an interval of 4-10 days throughout the growing season.	municipal, domestic or household wastewater	Three types of irrigation water i.e. municipal wastewater (MW), domestic wastewater (DW) and canal water (CW)	poplar		The tree species had much of the Cd concentration in its leaves followed by roots. Average metal distribution in different parts of P. deltoides (leaf, root and stem), decreased from leaf to root and stem with values of (15.6 mg kg-1), (13.96 mg kg-1) and (9.39 mg kg-1), respectively. Trees receiving the N equivalent of 279 kg ha-1 removed similar amounts of N and K as were applied in the DE. Leaf N concentrations of the plants in this study were higher than corresponding values reported by Weih and Nordh [19] for various willow clones in agricultural soil that received 20 and 150 kg ha-1 of Nitrogen. However, levels were within the same range as those of Salix viminalis grown on arable land amended with 150e300 kg ha-1 of Nitrogen in a study conducted by Jung et al. Leaf phosphorous	P. deltoides gained maximum plant height (4.40m) under DW irrigation which was 35% and 37% higher than the heights gained under MW (2.85 m) and CW (2.76 cm), respectively. Similarly, average collar diameter in response to DW irrigation (7.41 cm) was also 22% and 34% higher than the diameters gained under MW irrigation (5.81 cm) and CW (4.92 cm). The growth response clearly suggested that wastewater coming either from municipal or domestic source might add nutrients to the soil.	Based on the observations, all plants successfully survived upto 100% with each irrigation source applied. However, there was marked stress on growth because of application of MW. The water originated from a community when littered with a variety of refuse and loaded		Pakistan
115	Marta Marmiroli, Brett H. Robinson, Brent E. Clothier, Nanthi S. Bolan, Nelson Marmiroli, Rainer Schulin	X	2011	biomass production and filtration efficiency	Case study - Experimental set up - pilot-scale systems	Effect of dairy effluent on the biomass, transpiration, and elemental composition of Salix kinuyanagi Kimura	biomass production and filtration efficiency	Dairy Effluent- DE was applied for 15 weeks to eighteen 122 dm3 lysimeters, either bare or planted with S. kinuyanagi, at N application rates of 0e558 kg ha 1 over three months. DE application increased foliar concentrations of N, P, K, Cl, and the foliar N:S ratio to above 15, a level indicative of S deficiency. The total element concentrations of the tablets were determined at ETH Zu' rich, Switzerland, using a Spectro X-lab 2000 X-Ray Fluorescence (XRF) spectrometer.	industrial wastewater	Dairy Effluent (DE)	willow	A meteorological station installed in the greenhouse recorded temperature, solar radiation, and relative humidity.	The p0.5 treatment produced the highest shoot biomass. Leaf biomass as a percentage of total biomass (Table 4) was significantly higher in the p0.5 treatment. The higher proportion of leaf production upon DE application.	Potentially, dairy effluent could be irrigated onto stands of S. kinuyanagi to increase growth and produce nutritious biomass that could be fed back to the cows, thus resulting in increased nutrient cycling. The application of DE to S. kinuyanagi at rates up to the equivalent of 279 kg ha-1 of Nitrogen increased growth, transpiration, water use efficiency, and the percentage of biomass as leaves. There was a consistent increase in both the leaf and stem Cl concentration with increasing rates of DE application.		New Zealand	
116	R.J. Heaton, R.E.H. Sims, R.O Tungcul	X	2011	biomass	Case study - Experimental set up - pilot-scale systems	The root growth of Salix viminalis and Eucalyptus nitens in response to dairy farm pond effluent irrigation		The spatial root distribution after two years of three energy crops investigated, with the influence of two rates of dairy pond effluent application, applied ever fortnight. It was found that spatial distributio was influenced by effluent rate, with greater quantities of both fine and coarse roots in the top soi horizons with the higher effluent rate of 300 m3 ha1 compared to 150 m3 ha-1. The trees were planted in plots of 16, at 0.85 m2 spacing, which were irrigated with a micro sprinkler system.	industrial wastewater	dairy farm pond effluent irrigation	Eucalyptus, willow		In this study the biomass of roots was slightly lower than that of 3-3.5 mg cm-3 found in other studies on fertilised Eucalyptus. However, both the willow and eucalyptus were younger tha the trees in these other studies, and weree growing vigorously, producing up to 40 odt ha-1 yr-1.			New Zealand	

117	Pinchas Fine, Nir Atzmon, Fabrizio Adani, and Amir Hass	X	2006	biomass production and filtration efficiency	Case study - Experimental set up - pilot-scale systems	Disposal of sewage effluent and biosolids in eucalyptus plantations: a lysimeter simulation study	Two-hundred liters, sand-packed lysimeters were either applied with biosolids compost (at rates equivalent to 125 and 625 Mg/ha) or not applied, and 3-times daily surface drip irrigated with either oxidation ponds effluents or fertilized fresh water. Irrigation peaked at nearly 60 L/day-lysimeter. Lysimeters were planted with a Eucalyptus camaldulensis tree, and leaching of planted lysimeters was either intermittent or at leaching fraction (LF) of 0.2. Without a tree the LF was near 1. Results from the 2nd year of the experiment are presented.	municipal, domestic or household wastewater	sewage effluent	Eucalyptus camaldulensis		Applied nitrogen was nearly completely intercepted in the soil tree system, which was less efficient with respect to phosphorus. Eucalyptus system was very efficient in intercepting the environmental contaminants. The microbes were eliminated (or nearly so) under intermittent leaching. The recovery of N in the leachates from planted lysimeters was virtually zero, under all combinations of soil amendment, water types and leaching regime. Nitrogen recoveries in the leachate from the freshwater, fertigated lysimeters without a tree were ca. 100% of the amounts	Average dry weight of the 2nd year canopy regrowth (following cutting at the end of the 1st year) ranged from 9.4 to 18.8 kg/tree. we estimated that the water uptake (ET only) of a 2-year old, commercial Eucalyptus camaldulensis plantation at planting density of 1660 trees/ha (a 6 m <sup>2</sup> /tree planting grid) is approximately 1-m <sup>3</sup> /yr or 10 <sup>-4</sup> m <sup>3</sup> /ha-yr. The rate of N supply seems not to have limited tree growth. We derived this from the fact that reducing the water application rate (at intermittent leaching) reduced the N supply but did not necessarily decrease the sizes of the trees.	we demonstrated that Eucalyptus camaldulensis in the system studied was very efficient in intercepting nitrogen and phosphorus applied by irrigation or in combination with BC. This was despite the excessive rates of nutrient application (in the water and biosolids) and soil leaching.		Mexico
118	Michael Carlso	X	1992	biomass	Case study - Experimental set up - pilot-scale systems	Municipal effluent irrigation of fast-growing hybrid poplar plantations near vernon, british-columbia	Scott is currently harvesting these lands and replanting with the new very productive P. trichocarpa x P. deltoides clones from the Washington State Poplar Breeding and Research program. A large number of these hybrids are also in growth and adaptedness screening trials conducted by the B.C. Ministry of Forests. One community, Vernon, in B.C.'s southern interior is experimenting with hybrid poplars in a very different context. Municipal effluent or wastewater is being used to irrigate small-scale plantations as well as nearby grasslands. In the fall of 1985 Glyphosate was used to kill a heavy orchard grass cover on a 1-hectare area of research station property. This ground was then plowed and disked and a solid set overhead irrigation system installed using 8 cm aluminum pipe on a 12 m x 18 m grid with 2-m risers supporting 23 litre per minute rainbird sprinklers. This layout delivers approximately 2.5 cm of water per 4 hours of operation. Four thousand rooted cuttings of 22 T x D hybrid clones were produced and outplanted in spring of 1985 in 36-tree square plots at an initial spacing of 1 m x 1 m. Wastewater irrigation quickly resulted in luxuriant growth of both	municipal, domestic or household wastewater	Municipal effluent or wastewater - secondarily treated wastewater	cottonwood, aspen, birch and alder	Semi-arid. Annual precipitation averages 35 cm and is fairly evenly distributed throughout the year. Daily temperature averages in July and January are 20°C and -5 °C respectively. Vernon receives an accumulated heat sum of 2,011 degree-days on a 5°C base and enjoys a 170 frost-free day growing season.	Over the next two growing seasons more than half the damaged trees died. During the third year crowns closed and herbaceous vegetation declined, leaving less cover for the voles. This coupled with increasing numbers of predators resulted in a drop in rodent numbers and subsequent damage. By the end of the fifth field season (1990) plantation mean dbh and height were 10.6 cm and 13.6 m, respectively, with the top clone averaging 12.5 cm and 15 m. Mean annual volume increment appears to have reached a maximum of just under 15 m <sup>3</sup> /ha at age 4 years.			Canada	
119	OP Toky, Drusila Riddell-Black, PJC Harris, Padma Vaudevan and Philip A Davies	X	2011	biomass	Case study - Experimental set up - pilot-scale systems	Biomass production in short rotation effluent-irrigated plantations in North West India	In 2.5 y old plantations (plant spacing, 2 m x 2 m for single stem species and 2 m x 1 m for multi-stem species). There were four irrigation treatments and six species, replicated three times giving a total of 72 plots covering an area of 1.3 ha at Palwal. Individual tree plots m x m and tree species were completely randomized within each irrigation block, but irrigation treatments were not randomized. 48 plants per plot and 48 observation plants per plot. 42 Eucalyptus tereticornis and Ailanthus excelsa per plot and 20 observation plants per plot.	municipal, domestic or household wastewater	secondary treated sewage water	Melia azedarach, Pongamia pinnata and Alstonia scholaris. Eucalyptus tereticornis and Ailanthus excelsa	semi-arid max. Temp. 10-36 °C and min. Temp 6-19 °C.	Melia azedarach showed fairly high biomass production (38,4 t/ha - 15.36 t/ha/y) followed by Ailanthus excelsa (27.2 t/ha - 11 t/ha/y). Order of biomass production (kg/tree) was: Eucalyptus tereticornis (24.1)> A. excelsa (21.8) > M. azedarach (12.6) > Populus deltoides clone G48 (8.3) > Alstonia scholaris (6.6) > Pongamia pinnata (3.7). Survival of plants after 2.5 y ranged from 25.2% in P. deltoides to 71.7% in P pinnata, and had a significant effect on biomass production per util area. Survival after 2.5 year varied from 25,2% in P. deltoides clone G48 to 71,7% in P. Pinnate. Highest weight was of individual tree of E. tereticornis (24,1 kg/tree) followed by A. excelsa (21.8 kg/tree) with the low values of P. pinnata (3.7 kg/tree).	High density plantations after 2,5 years in present study carried out at Palwal, accumulated fairly hig amount of above-ground biomass up to 3, t/ha in M azedarach (15.36 thay) and 27.2 tha in Ailanthus excelsa (11 tha/y).		India	



120	Patrick J. Minogue, Masato Miwa, Donald L. Rockwood and Cheryl L. Mackowiak	X	2012	Phytoremediation	phytoremediation	Removal of nitrogen and phosphorus by Eucalyptus and Populus at a tertiary treated municipal wastewater sprayfield	Evaluate fast-growing tree species and genotypes for phytoremediation of N and P from tertiary treated municipal wastewater and biomass production for energy 2 hr daily irrigation 93.8 m3 ha-1 d-1 (9.4 mm d-1) -2.73 mg L-1 NOx-N -6.52 mg L-1 total N -0.30 mg L-1 total P 5 Selected P. deltoides clones, 27-months-old.	municipal, domestic or household wastewater	tertiary treated wastewater	Populus and Eucalyptus		max. Temp. >80 °F in Agust. Freezing days on december and february	Percentage removed 215% of Nitrogen and 615% of Phosphorus	October 2008, 7 months from planting •All species grew approximately 3 m •Survival was greater than 96% •E. grandis> P. deltoides> E. ampifolia Populus deltoides has potential for high biomass production and phytoremediation of N and P discharge from tertiary treated wastewater. •69% Main Stem •14 % Woody Branches •13% Foliage •4% Green Branches From other work, biomass partitioning changes with age. •11 Month old – 40% stem •6 Year old – 80% stem	Low biomass producing clones had the greatest nutrient concentrations, but high biomass producing clones effectively removed more N and P. A significant amount of N and P was accumulated in the main stems and foliage, suggesting whole tree harvest following full leaf development in the spring may optimize N and P removal.		USA
121	Kro"o"t Aasamaa, Katrin Heinsoo, Bert Holm	X	2010	biomass	Case study - Experimental set up - pilot-scale systems	Biomass production, water use and photosynthesis of Salix clones grown in a wastewater purification system	An objective of the study was to identify leaf morphophysiological characteristics indicative of high aboveground woody biomass production of Salix clones growing in the vegetation filter of a wastewater purification system.	municipal, domestic or household wastewater	pre-treated municipal wastewater	willow		The climate of the area is cool-temperate, the growing season lasts 5–6 months, the annual sum of active temperatures (over 10 °C) is 1750–1900 °C, the annual precipitation is w600 mm, of which w350mm is rain during the growing season.		In the most productive clones, the vertical gradient (through foliage) of values of almost all the characteristics (daily decrease in water potential, stomatal conductance and sensitivity, hydraulic conductance; daily minimum and maximum water potentials, use efficiency, maximum rate of photosynthetic electron transport, chlorophyll content, and the partitioning coefficient for leaf nitrogen into bioenergetics associated with electron transport) was the smallest.	They conclude that the characteristics of photosynthesis light stage – high maximum rate of photosynthetic electron transport, high chlorophyll content, and also flat vertical gradient (through foliage) in values of the characteristics could be the strongest indicators of high biomass production of Salix clones growing in vegetation filter. They suggest that the characteristics of light stage photosynthesis apparatus – Jmax (maximum rate of photosynthetic electron transport) and chlorophyll (especially chlorophyll a) content are most		Estonia
122	Agnieszka Karczmarczyk & Józef Mosiej	X	2010	biomass	full-scale systems	Aspects of wastewater treatment on short rotation plantations (SRP) in Poland	The number of SRP and their area in Poland has been growing in the last years. According to the data of the Ministry of Agriculture and Rural Development, about 6000 ha of agricultural land was covered by Salix sp and Rosa multiflora var plantations in 2005. At the end of 2004 over 2000 wastewater treatment plants were operated, with average flow between 50 and 100 000 m3 d–1. It is estimated that there is an area of about 3 000 000 ha of abandoned land in Poland, because of fulfilling a market for traditional agricultural food crops during the last years. However, only about 1 000 000 ha is characterised by conditions favourable for energy plant.	municipal, domestic or household wastewater	wastewater treatment	willow					Within renewable energy sources available in Poland, biomass seems to have the largest potential, estimated to 90%. With average vegetation period from 210 days (Gdańsk) to 215 days (Kraków) and precipitation of 500–700 mm the natural productivity of willow can be as high as 14 Mg d m per ha.		Poland

123	U. Kotowska, T. Włodarczyk, B. Witkowska-Walczak*, P. Baranowski, C. Sławiński	X	2008	Filtration efficiency	Case study - Experimental set up - pilot-scale systems	Wastewater purification by muck soil and willow (Salix americana)	The aim of the present work was to investigate ammonium and nitrate(V) fixation by soil irrigated with communal wastewaters and estimation of the possibility of using organic soil and willow (Salix americana) for wastewater purification. The experiment included a number of plants and covered the area of 8 ha. For irrigation the wastewaters were applied in suitable doses, i.e. the full single dose was 900 mm, the double dose was 1800 mm, and the number of doses applied was 12 (flooded 4 times in the spring, summer and autumn).	municipal, domestic or household wastewater	communal wastewaters	willow	ammonium and nitrate	It was concluded that the studied soil and the plant applied showed very high capacity of binding ammonium ions (up to 96%), and lower in the case of nitrates(V) (up to 69%). Concentration of analyzed ions (NH <sub>4</sub> <sup>+</sup> and NO <sub>3</sub> <sup>-</sup> ) in drainage waters from the control plot varied only slightly in time. Analyzing the percentage of absorbed ammonium ion, one can find that the studied object had a very high capacity for reducing the concentration of NH <sub>4</sub> <sup>+</sup> ions in the wastewaters. That percentage varied from 56 to 95% and from 92 to 95%, respectively, for the first day from the		It was found that the highest biological and physical purification effect by studied soil and plant was observed after the first 24 hours from the moment of the wastewaters application. It was also demonstrated that a single irrigation dose was better utilized than a double dose. An effect of the season of the year on the final purification effect was observed.		Poland
124	V. kuusemets, K. Heinsoo, E. sild & A. kopp	X	2001	Filtration efficiency	Case study - Experimental set up - pilot-scale systems	Short rotation willow plantation for wastewater purification: case study at Aarike, Estonia	This paper describes a small pilot system where wastewater is treated in constructed wetland planted with willows. The total area of the system was 180 m <sup>2</sup> . From the tanks wastewater was directed to the constructed wetland consisting of three basins. Each basin was divided into four beds	municipal, domestic or household wastewater	wastewater treatment	willow	N, P (BOD, NH <sub>4</sub> -N, NO <sub>3</sub> -N, Kjeldahl-N, Pod-P, total-P, Total-N)	During the study period (1995-2000) the average purification efficiency of BOD, total N and total P in Aarike constructed wetland was 75, 32, and 14%, respectively. <b>The average purification efficiency of BOD for the whole study period was 75%. The purification efficiency was smaller during cold period.</b> An average reduction in ammonium nitrogen in Aarike was 24%. In average 32% of total nitrogen was removed during the study period. The average purification efficiency was 14% for total-P and 8% for PO <sub>4</sub> -P.	The average annual plant wood dry matter production for the second rotation period was 1.16 kg, which exceeded the productivity in the fertilised plantation in the same region (0.7 1 kg). During the second rotation period (1998-2000), when only 23% of Salix viminalis survived, the average annual Wood dry matter-WDM was 1155 g DM per plant.	The system showed high wood productivity and also high wastewater purification efficiency. The pilot study in Aarike demonstrated that willows can be used in constructed wetlands for wastewater purification. The wintertime efficiency of constructed wetland and also the amounts of phosphorus and nitrogen removed could be increased by extending the wetland area and by increasing the retention time.		Estonia
125	Catherine Mant, John Peterkin, Eric May, John Butler	X	2003	biomass production and filtration efficiency	Case study - Experimental set up - pilot-scale systems	A feasibility study of a Salix viminalis gravel hydroponic system to renovate primary settled wastewater	A Salix viminalis/gravel system based on hydroponics was developed for wastewater renovation in order to avoid the problems of soil damage and pollution associated with long-term application of wastewater to soil. The treatment solutions were changed weekly, over a period of 19 weeks. The experimental layout was a randomised block containing 3 replicates of each treatment.	municipal, domestic or household wastewater	wastewater	willow		This system (Salix/gravel) under investigation achieved treatment efficiencies for unamended wastewater of 90% for BOD, 57.7% for nitrogen, 90.6% for phosphorus and 24.9% for potassium.	Highest growth rates and yields are generally seen when nitrogen is supplied as a combination of ammonium and nitrate. the dry weight of new shoots produced was five times greater than that produced by the trees growing in the unamended wastewater. The root:shoot ratios were calculated as 0.45 for the trees in the nutrient solution, 0.80 for those in the wastewater, 0.86 for those in the wastewater amended with 10 ppm copper and 1.10 for the trees growing in the wastewater amended with 100 ppm copper.	The trees were also unaffected by copper at a concentration of 10 ppm.		UK



126	P.S.Minhas, R.K.YadavK.Lal, R.K.Chaturvedi	X	2015	biomass production and filtration efficiency	Case study - Experimental set up - pilot-scale systems	Effect of long-term irrigation with wastewater on growth, biomassproduction and water use by Eucalyptus (Eucalyptus tereticornis Sm.)planted at variable stocking density	Therefore, the growth patterns, biomass production, water use and changes in soil properties were evaluated for a 10-year rotation of Eucalyptus (Eucalyptus tereticornis Sm.) plantations of variable stocking density and irrigated with either sewage (SW) or a good quality groundwater (GW). The irrigated trees grew rapidly and the stock volumes attained after 10 years were 164.0 and 127.1 m <sup>3</sup> ha <sup>-1</sup> with SW and GW, respectively. The experiment was conducted at Research Farm of Central Soil Salinity Research Institute, Karnal, Haryana, India	municipal, domestic or household wastewater	wastewater	Eucalyptus		The site has subtropical semi-arid monsoonal climate with about 80% of rainfall occurring during the months of July to September. The mean monthly temperature is the maximum in May or June and the minimum during January.	Amongst various tree parts, tree bole contributed more than 90% of the above ground C absorption and 61–71% of the total C absorbed (including below ground); while contribution of below ground biomass ranged between 23 and 33% of the total C stock. The total C removed was about 7% more in plantation irrigated with SW.	The tree growth improved with stocking density and the maximum shoot biomass (262 Mg ha <sup>-1</sup> ) was produced under high (HD, 1993 stems ha <sup>-1</sup> ), followed by the recommended (RD, 517 stems ha <sup>-1</sup> ; 178 Mg ha <sup>-1</sup> ), very high (VHD, 6530 stems ha <sup>-1</sup> ; 127 Mg ha <sup>-1</sup> ) and low stocking density (LD, 163 stems ha <sup>-1</sup> ; 55 Mg ha <sup>-1</sup> ). The plantations grew rapidly when irrigated with either sewage (SW) or ground (GW) water. Major increments in growth parameters were monitored during the four months of May to August which accounted for 49–61% of annual growth while the growth slowed down during the months of October–December, contributing only 13%.	It is concluded that Eucalyptus plantations can act as potential sites for year round and about 1.5 fold recycling of sewage than the annual crops. However, cautions, rather regulatory mechanism should be devised to control loading rates since these are not as profligate consumers of water as has been claimed.		India
127	RODRIGO A. Z. PELISSARI, SÍLVIO C. SAMPAIO, SIMONE D. GOMES, MAURO DA S. CREPALLI	X	2009	biomass production and filtration efficiency	Analysis	Textile residue and wastewater from swine culture on the eucalyptus production	The objective of this work was to evaluate the effects of textile silt, seasoning and irrigation with wastewater from swine activities on the production of Eucalyptus. a total of 90 days of production. The irrigation was performed by aspersion, with 12 mm day <sup>-1</sup> .	industrial wastewater	wastewater from swine activities	eucalyptus				The wastewater from swine culture presented the best results for the samples at diameter and at height. The plant height parameter showed the best response to the treatments. The irrigation water factor indicated that the swine wastewater produced the greatest positive effects for diameter and, mainly, for plant height.			Brazil
128	Michael Duncan	X	1998	biomass production and filtration efficiency	case study - Experimental set up - pilot-scale systems	Wastewater irrigated tree plantations: Productivity and sustainability	This paper presents data collected to age 4 years, incorporating coppice regrowth to age 1 year in the 3-year rotation.	municipal, domestic or household wastewater	effluent irrigation	Eucalypt		Max. rainfall 622 mm and min. 354 mm.	Total N in the surface 15 cm of soil decreased to 60-80% of initial concentrations after 3 years of irrigation suggesting that mineralisation of N has been significant. The loss of N was associated with loss of soil C, and generally soil C to N ratios did not change. Total P concentrations in soil increased by 9 to 18% at all depths analysed.	At age 4 years, growth rates and biomass production in this trial are amongst the highest reported in Australia. Survival and growth of both E. globulus and E. grandis is excellent, with survival varying between 86 and 96%, and average volume growth of E. globulus (126 m <sup>3</sup> /ha) being approximately 1.4 times that of E. grandis (91 m <sup>3</sup> /ha) to age 4 years. At age 4 years, N accumulation was high in both E. globulus and E. grandis, varying between 320 and 450 kg/ha across species and densities. More than half of the accumulated N was held in foliage.	Tree volume growth trends to age 4 years for both species indicate that the Short Rotation Coppice Trial is amongst the most productive eucalypt plantations in Australia. The projected biomass production for a 12 year cycle of rotations at 3-, 6- and 12-years is 330, 390 and 350 Mg/ha respectively for E. globulus growing at an estimated peak MAI of 45 m <sup>3</sup> ha <sup>-1</sup> yr <sup>-1</sup> .		Australia
129	L.B. Guo, R.E.H. Sims	X	2003	Effects on soil, Filtration efficiency - bioremediation of effluents	Case study - Experimental set up - pilot-scale systems	Soil response to eucalypt tree planting and meatworks effluent irrigation in a short rotation forest regime in New Zealand	The objective of the current study was to determine the effect on soil of planting various eucalypt species, and effluent irrigation, during the first 3-year rotation of coppiced short rotation forests. The study concentrated on changes in the top soil (0–75 mm) over the 3-year period since the upper soil layers are more sensitive to	industrial wastewater	meatworks effluent	eucalypts		Mean average annual rainfall is 1098 mm. The distribution of mean monthly rainfall ranges from 60 mm in February to 123 mm in December. Mean	Tipler et al. (1996) reported that 10 year meatworks effluent irrigation raised soil organic matter content by 40% (from 4.9% to 6.75%) under pasture. The organic	Tree planting increased soil organic matter with time, and effluent irrigation appeared to enhance the increase. However, the changes in the soils receiving effluent at the end of the 3-year period in the current study should also be attributed to the nutrient input from litter fall, being up to 13.4 oven dry t/ha/year.	The bulk density was consistently lower under trees irrigated with effluent than under trees without irrigation during the whole rotation. Across the three species, the soil bulk		New Zealand
130		X				Wastewater Treatment and Wood Production of Willow System in Cold Climate	This article studied how wastewater treatment performance of a short rotation forestry system was influenced by the seasonal operational changes under the extreme Mongolian winter conditions. For this reason, two beds planted with Willow (Salix spec.) and Poplar (Populus spec.) trees were operated over a period of two years under two different seasonal conditions: (A) "external winter storage" and (B) "internal winter storage" of pretreated wastewater.	municipal, domestic or household wastewater	primary treated wastewater	poplar and willow			In winter, the wastewater accumulated as ice in the tree-bed. Bed A, with external winter storage, showed mass removal percentage up to 95%, while the bed with internal winter storage showed mass removal rates up to 86% for pollutants such as COD, BOD5, TN, and TP.				Mongolia

131	M.D. Tomer, L.A. Schipper, S.F. Knowles, W.C. Rijkse, S.D. McMahon, C.T. Smith, A. Thorn, and T. Charleson	X	1997	biomass production and filtration efficiency	full-scale systems	A land-based system for treatment of municipal wastewater at Whakarewarewa Forest, New Zealand	Wastewater is sprinkler-applied through an irrigation system that covers 242 ha of nearby Whakarewarewa Forest (5,667 ha). The forest is currently managed by Fletcher Challenge Forests for production of radiata pine, and the wastewater provides nitrogen and phosphorus to the tree crop. The irrigated area is divided into 14 blocks, with two blocks being irrigated each day in a weekly rotation. The average application is about 50 mm of water per week, and annual nutrient loadings average about 300 kg N/ha and 60 kg P/ha. the tertiary effluent from the treatment plant is pumped 3.3 km to two storage ponds in Whakarewarewa Forest that are 120 m higher than the treatment plant. The area is commercially forested for pine with a production on 25-30 year rotations. area 276 ha and is divided into 16 blocks of approx. 17 each.	municipal, domestic or household wastewater	municipal wastewater-tertiary treatment	pine		Average annual precipitation at Rotorua airport (6 km from the irrigated area) is 1491 mm. Precipitation is reasonably uniform throughout the year; monthly averages range from 94 mm in January to 161 mm in August. Mean annual temperature is 12.7 C, with monthly averages ranging from 17.8 C in February to 7.5 C in July	Clear differences in rate of nitrate removal were observed, with 50% nitrate removal occurring within 10 hours in the swamp, and within 68 hours in the pond. Table 2 %PT retention.				New Zealand
132	S. Braatz and A. Kandiah	X	1996		Analysis	The use of municipal waste water for forest and tree irrigation	Large-scale, controlled waste water use for irrigation, however, only dates back to last century when so-called sewage farms <sup>2</sup> were established in parts of Europe, Australia, India and the United States for the purpose of disposing of waste water and preventing river pollution. Examples of farms where tree plantations were irrigated with waste water, such as the El-Gabal El-Asfar farm in the Cairo. The farm by that time had increased in size to 1 260 ha. Untreated sewage was used in Kuwait for many years to irrigate forestry plantations. treated municipal waste water on forest lands as a means of purification and groundwater recharge were carried out in central Pennsylvania. Australia is also increasingly using land application as an effective way to dispose safely and productively of secondary treated waste water. A test plantation of eucalyptus (background) and poplars (foreground) irrigated with waste water in India	municipal, domestic or household wastewater		poplar & eucalyptus			Poplars, which were found to be the most suitable species in terms of nutrient uptake, ability to withstand flooding in the dormant period and economic wood production, are managed on a 12-year rotation for timber. This system is being adopted elsewhere in Spain.	These factors, combined with a high demand in many developing countries for fuelwood and construction materials to supply their growing numbers of low-income urban dwellers as well as rising market prices for timber, have led to a growing interest in the possibility of waste water-irrigated tree plantations.			Egypt
133	Hayssam M. Ali, EL-Sayed M. EL-Mahrouk, Fatma A. Hassan, and Mohamed A. EL-Tarawy	X	2010	biomass production and filtration efficiency	Case study - Experimental set up - pilot-scale systems	Usage of sewage effluent in irrigation of some woody tree seedlings. Part 3: Swietenia mahagoni (L.) Jacq.	The study lasted for 18 months from June 2003 to December 2004, to investigate the effects of irrigation with different treatments of sewage effluent on the vegetative growth and chemical composition of S. mahagoni (L.) Jacq. and soil chemical properties for three periods (6, 12 and 18 months). The three treatments were replicated three times, and each repetition contained four seedlings.	municipal, domestic or household wastewater	primary and secondary effluents	mahagoni		arid and semi-arid countries.	The primary effluent treatment showed the highest concentration and total uptake of N, P, K, Cd, Ni, Pb and Fe in plant parts, followed by secondary effluent then tap water. sewage effluent decreased the CaCO <sub>3</sub> content from 32.04% to 28.48% and 27.59% for primary and secondary effluent treatments, respectively, after 18 months of irrigation period.	The primary effluent treatment was superior than other treatments in improving the growth parameters (plant height, stem diameter, leaf area, leaves number, fresh and dry weights of leaves, shoots and roots and shoot/root ratio)	The results suggested that the use of sewage effluent in irrigating mahogany trees grown on calcareous sandy loam soil was an important agriculture practice for improving soil properties, increasing fuel and timber production, and is an economic and safe way to dispose wastewaters.		Egypt
134	Martin M. Karpiscak, and Gerald J. Gottfried	X	2000	biomass	Case study - Experimental set up - pilot-scale systems	Tree Production in Desert Regions Using Effluent and Water Harvesting	This paper describes initial observations from the Arizona study and focuses on the tree survival rates and growth under different irrigation regimes.	municipal, domestic or household wastewater	Treated municipal effluent combined with water harvesting	velvet ash, black willow, Fremont cottonwood, Arizona sycamore, eucalyptus and Mondell pine			Nearly 100% survival was achieved for pine, cottonwood and willow, regardless of the water mix. Ash had about an 80% survival rate overall while sycamore had about 60%. These rates for ash and sycamore are higher than the 30% and 50% survival rates observed in August 1997. In Arizona, all species except eucalyptus grew more in the field plots compared to growth in the containers when irrigated with effluent. Initial results have shown that some species, especially cottonwood and willow in the field, grew to heights of 230 to 300 cm within 12 months of planting.	Field tree survival rates in Arizona were 80% to 100% for most species. These results indicate the potential for use of effluent for growing selected tree crops for wood production, aesthetics and environmental benefits.			USA



135	P.Hopmans, H.T.L.Stewart, D.W.Flinn, T.J.Hillman	X	1990	biomass production and filtration efficiency	Case study - Experimental set up - pilot-scale systems	Growth, biomass production and nutrient accumulation by seven tree species irrigated with municipal effluent at Wodonga, Australia	A study was carried out at Wodonga in which seven tree species were irrigated with effluent for a period of 4 years.	municipal, domestic or household wastewater	municipal effluent	Eucalyptus camadulensis Dehnh, E. grandis W. Hill ex Maiden, E. saligna Sm, Casuarina cunninghami ana Miq, Pinus radiata D. Don, Populus deltoides Bartr. ex Marsh and P. deltoides×P, nigra L.	Annual irrigation varied between 1190 mm and 1750 mm with a total input over the 4- year-period of 4940 mm. Maximum and minimum mean monthly temperatures are 31.9°C in January and 3.0°C in July. Mean annual pan evaporation is 1786 mm.	Accumulation of nutrients in the above- ground biomass varied significantly between species and ranged from 24 to 41 g m <sup>-2</sup> for N, 2.6 to 5.9 g m <sup>-2</sup> for P, 0.5 to 9.2 g m <sup>-2</sup> for Na, 12 to 27 g m <sup>-2</sup> for K, 7 to 52 g m <sup>-2</sup> for Ca and 3.1 to 7.9 g m <sup>-2</sup> for Mg. Nutrient accumulation was generally greater in species with a comparatively large crown biomass relative to stem size such as C. cunninghamiana and E. camadulensis. Average nutrient accumulation by trees as a percentage of input from effluent was estimated at 19% for N, 9% for P, 1% for Na, 14% for K, 52% for Ca and 32%	Height and diameter growth varied significantly between species. At age 4, mean dominant height of Eucalyptus grandis, E. saligna and Populus deltoides × P. nigra ranged from 14.3 to 15.0 m compared with 6.6 to 9.8 m for Casuarina cunninghamiana, E. camadulensis, P. deltoides and Pinus radiata. Wood production of the faster-growing species (E. grandis and E. saligna) was approximately 130 m <sup>3</sup> ha <sup>-1</sup> , or around 32 m <sup>3</sup> ha <sup>-1</sup> year <sup>-1</sup> over a 4- year period. This was nearly three- fold the production of the other native species and twice that of P. radiata. Volume growth of P. deltoides × P. nigra (85 m <sup>3</sup> ha <sup>-1</sup> ) was significantly greater than that of P. deltoides (42 m <sup>3</sup> ha <sup>-1</sup> ).	Results of this study indicate the importance of selecting species on the basis of not only growth but also nutrient accumulation to optimise renovation of wastewater by tree plantations.		Australia
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