



Wastewater Treatment: From Cost Centre to Strategic Investment

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Abstract

For a long time, urban wastewater treatment has been treated as a purely “defensive” sector: a cost centre necessary to comply with environmental standards and reduce the impact of discharges on rivers and seas. However, in a historical phase marked by increasing water stress, extreme weather events and ecological transition, the scope of the problem is shifting: wastewater is no longer just waste to be managed, but a resource to be valued. Therefore, this work aims to assess whether and to what extent purification can be reinterpreted as a strategic investment, capable of generating environmental, health and economic benefits. The research is based on a qualitative methodology supported by quantitative evidence, based on European and national institutional documents, comparable series and indicators, as well as on case studies relating to water reuse, energy recovery and nutrient recovery. The research questions concern: (RQ1) the overall economic return on investments; (RQ2) the contribution of purification to the circular economy; (RQ3) the costs of non-intervention, including sanctions, environmental damage and waste of resources. The expected results indicate a positive social balance of investments, especially where purification enables reuse, energy autonomy and recovery chains. The policy implications concern the need for multi-year planning, strengthening of governance and priority for the South, where the infrastructural deficit feeds a vicious circle of fines, environmental degradation and lower territorial attractiveness.

Keywords: Purification, Circular economy, Strategic investments, development

Introduction

The management of urban wastewater has always been an essential hub in the functioning of cities: an "invisible" service as long as everything is working, but which suddenly becomes evident when it jams, producing immediate effects on the environment, public health, quality of life and even the reputation of the territories. Yet, despite its centrality, purification has often been confined to a logic of compliance: a cost to be incurred because it is imposed by the rules, an infrastructure to be "brought up to standard" to avoid litigation, an unpopular and therefore easy expenditure item to postpone.

This approach, although understandable in the short-term political dynamic, has produced a result that Italy knows well: infrastructural delays, management discontinuity and European infringement procedures that transform non-investment into a certain, repeated and growing cost. By way of example, in 2018 the EU Court of Justice sanctioned Italy with a lump sum of 25 million euros and a penalty of more than 30 million for each six-month delay, due to the failure to adapt agglomerations that had already been the subject of a previous conviction (Court of Justice of the European Union, 2018). And in the following years, the complaints did not end: new sentences and new penalties indicate that the issue is not episodic, but structural.

In parallel, the reference context has undergone a structural transformation. Drought is no longer an extraordinary event, but a recurring and systemic condition (Redazione Marketing, 2026). The competition between civil, agricultural and industrial uses of water resources has intensified; the European Union is increasingly determined to orient environmental policies towards models based on closing cycles, reducing pollution, recovering materials and energy and reusing wastewater where technically and economically sustainable.

Purification, therefore, can no longer be interpreted exclusively as an intervention "downstream" of the production process, aimed at merely complying with regulatory limits. Rather, it can take on the configuration of an enabling platform for the circular economy: treated water as a reusable resource, sludge as an energy carrier, nutrients as secondary raw materials. In other words, the transition is outlined from a defensive paradigm - focused on minimizing the risk of sanctions - to a proactive paradigm, in which investment in environmental infrastructure becomes a tool for generating value, territorial resilience and long-term sustainability.

The objective of this work starts from these premises: to verify whether purification, rethought according to advanced technological and

management criteria, can evolve from a cost center to a strategic investment, in particular in territorial contexts in which the infrastructural deficit has contributed to consolidating an economic and social gap of a now structural nature.

Context

The European Framework: From environmental compliance to circular transition

The European regulatory context has historically been dominated by Directive 91/271/EEC on the treatment of urban waste water, built with a clear objective: to protect the environment from the effects of insufficiently treated wastewater. However, in recent years, the European political trajectory has added a further level: it is not enough to negotiate, we must also recover, make more efficient and decarbonise.

This evolution is well represented by Directive (EU) 2024/3019 (recast), which explicitly links purification to energy, emissions and resource recovery objectives, introducing a progressive logic towards the energy neutrality of plants, as well as new attention on micropollutants and extended producer responsibility for specific sectors (European Parliament and Council of the European Union, 2024). It is not a technical detail: it is a change in cultural approach, because it implies that a purifier is no longer considered just an operating cost, but a "production infrastructure" that must measure itself with energy performance, recoveries and system results.

On the reuse side, Regulation (EU) 2020/741 of the European Parliament and of the Council takes on central importance, which establishes harmonized minimum requirements for the safe reuse of treated wastewater for irrigation purposes in agriculture (European Parliament and Council of the European Union, 2020). This regulatory intervention is part of a broader European strategy aimed at the integrated and sustainable management of water resources, based on criteria of health safety, traceability and management responsibility.

Reuse can no longer be considered a marginal or merely possible option. In areas characterized by structural water scarcity, the failure to exploit treated wastewater ceases to be a neutral choice and instead translates into a form of systemic inefficiency, with long-term economic, environmental and territorial implications.

Necessary Investments and “Cost of Inaction” Risk

An element often underestimated in the public debate concerns the economic scale of the adjustment. The European Commission, recalling OECD estimates, highlights that to achieve and maintain compliance with the waste water directive, additional investments in the order of hundreds of

billions are needed in Europe in the decade 2020–2030 (European Commission, 2020). This data, read superficially, can fuel resistance (“too expensive”). But read correctly it poses a different question: How much does it cost not to do so?

In the Italian case, the dimension of the problem emerges clearly in the sanctions: the 2018 conviction (Case C-251/17) is an emblematic step (Court of Justice of the European Union, 2018), and subsequently the Court returned to sanction Italy in 2025 for further non-compliance, with new lump sums and six-monthly penalties (see the journalistic reconstructions based on documents and rulings, for example e.g. Eunews, 2025). Furthermore, national institutional sources (e.g. ministerial portals on infringement procedures) show how non-compliance remains significantly concentrated in the southern regions, fueling an infrastructural fracture which also becomes a development fracture (Ministry of the Environment and Energy Security, n.d.).

Methodology

The research adopts a qualitative methodology supported by quantitative evidence, built on three pillars:

1. Institutional and regulatory documentary analysis, with reference to: EU directives and regulations, European Commission reports, evaluation documents on the sector and rulings of the Court of Justice. This basis serves to define constraints, trajectories and "mandatory" objectives of the policy.
2. Use of indicators and quantitative estimates obtained from comparable sources: OECD estimates on necessary investments, WHO/literature estimates on the economic benefits of water and sanitation investments, and data on reuse/energy/recoveries from technical sources and sector reports. In particular, for the benefit-cost dimension we recall works that estimate high cost-benefit ratios for investments in sanitation services (Hutton & Varughese, 2013).
3. Cases and evidence of circular economy: water reuse (international benchmarks), energy recovery (biogas/biomethane and energy neutrality) and nutrient recovery (phosphorus and nitrogen), considered as concrete channels for transforming the purifier into a "productive" platform.

The research questions (RQ) guide the integrated reading of the results:

- RQ1: economic and social return on investments;
- RQ2: contribution to the circular economy (water, energy, nutrients);
- RQ3: costs of non-intervention (fines, damages, waste).

Results

Economic Benefits: Because purification is "worthwhile" even when it seems like it's just an expense

The first result, perhaps the most important, is that purification generates benefits that are rarely accounted for with the same visibility as the costs. And here a decisive methodological point comes into play: when we talk about "return", we are not just referring to direct monetary revenues, but to overall benefits for the community.

International literature, for example, shows that investments in water and sanitation services can produce multiple economic returns: in a widely cited estimate, the global benefit-cost for the "sanitation" component is equal to approximately 5.5 dollars for every dollar invested, considering reduction of illnesses, productivity and other social effects (Hutton & Varughese, 2013). This data should not be read mechanically, but as an indication of a point: neglecting the water and purification infrastructure produces externalities which, sooner or later, re-emerge in the form of health, environmental and economic costs.

Table 1 highlights how purification cannot be reduced to a simple expense item. The benefits associated with investments systematically exceed the costs incurred, both in terms of health and productivity, and in terms of added value and employment. In particular, the cost-benefit ratio estimated by the WHO shows that every euro invested produces multiple returns for the community, confirming the strategic nature of the sector.

Table 1: Items and estimated values

Voice	Estimated value
Health Benefits and Productivity (WHO)	€5.5 benefit for every €1 invested
Net benefits of water investments in Italy (to 2050) \approx 3,1 billion €	
Added value of the water service	16,5 billion € / year
Occupation activated	>150.000 employees

Source: Own elaboration

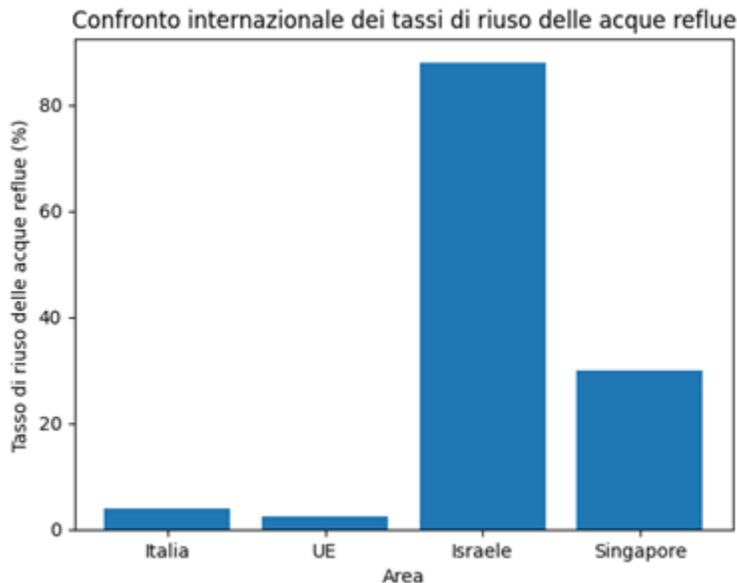
In parallel, the macroeconomic dimension of the water sector is anything but marginal: the most recent sector reports in Italy underline how the "extended supply chain" of water activates very significant economic values and a broad employment base, with direct and indirect effects (The European House - Ambrosetti, Utilitalia, & partner of Community, 2025). The point, here, is not to replicate a complete sectoral balance sheet, but to highlight a logic: investing in purification does not just mean building plants, but moving supply chains, qualified work, technologies, and above all reducing territorial vulnerabilities.

Purification and Circular Economy: The "hidden" value in water, energy and nutrients

Here the second piece of evidence emerges: modern purification is no longer a linear process (collect-treat-discharge), but can become a circular system. Water reuse. In Europe, reuse is still limited, despite the potential: the European Commission recalls that the volumes reused could be many compared to current levels, precisely due to the water scarcity which already affects a significant portion of the population (European Commission, n.d.). In Italy, sectoral estimates and reconstructions highlight a large gap between potential and actual use, with reuse still reduced compared to the volumes treated (Legambiente, 2023). International benchmarks show that very high shares are technically possible: in the case of Israel, technical documents indicate that almost 90% of treated wastewater is reused, especially in agriculture (U.S. Environmental Protection Agency, 2023). The message is simple: the limit is not the "possibility" itself, but the combination of infrastructure, standards, governance and acceptability.

Figure 1 immediately highlights the structural delay of Europe and, in particular, Italy in the reuse of waste water compared to countries that have made water scarcity a driver of innovation. The comparison with Israel and Singapore demonstrates that very high levels of reuse are not utopian, but the result of strategic choices and consistent investments over time.

Figure 1: International comparison of wastewater reuse rates



Source: Own elaboration

Energy from sludge and energy neutrality. Purification is energy-intensive: the European Commission has estimated that the sector uses

around 0.8% of the EU's total energy (European Commission, 2019). But this data, if read well, already contains a second piece of information: if the sector consumes so much, then it also has significant potential for efficiency and self-production. This is where anaerobic digestion, biogas, and integration with renewables come in. The new Directive (EU) 2024/3019 makes this orientation more stringent and progressive, shifting the axis towards energy and emissions reduction objectives (European Parliament and Council of the European Union, 2024).

Nutrient recovery. The third channel is the one which, in perspective, could change the very perception of purifiers: no longer "disposal" plants, but "urban mines". Scientific studies show that phosphorus contained in urine and feces, if collected and recovered, could cover approximately 22% of global phosphorus demand (Mihelcic et al., 2011). This is an enormous figure, because it reconnects purification to the safety of supply chains and the reduction of eutrophication, i.e. one of the heaviest and least immediately visible environmental costs.

Table 2 highlights the large gap between current and potential use of the resources contained in wastewater. In particular, water reuse and energy and nutrient recovery are still largely underused, despite the fact that they can significantly contribute to water, energy and agricultural security. This gap represents one of the main missed opportunities of the current system.

Table 2: Estimated potential

Scope	Current situation	Estimated potential
Wastewater reuse (Italy)	≈ 4%	≈ 23–45% irrigation needs
Reuse waste water (UE)	≈ 2,4%	≈ 15–20% of the volumes treated
Energy production da fanghi (Italy)	Limited	≈ 2 TWh/ year
Phosphorus recovery (global)	Marginal	≈ 22% of global demand

Source: Own elaboration

Costs of Non-Intervention: When "saving" becomes the most expensive choice

The third evidence is almost specular: if investing produces returns, not investing produces costs. And here the costs are of two types: those that are immediate and accounted for, and those that are widespread and often downloaded over time.

On the immediate front, the Italian case is emblematic: the 2018 conviction (C-251/17) provides for six-monthly penalties and a significant lump sum (Court of Justice of the European Union, 2018). Subsequently, new non-compliances generated further convictions and sanctions (Eunews, 2025). In essence, the failure to spend on works converts into a "sterile" expenditure in fines.

On the widespread side, however, environmental and health costs are more difficult to make politically visible, but no less real. For reactive nitrogen pollution, for example, the European literature estimates very high overall annual damages, with an order of magnitude reaching hundreds of billions (Sutton et al., 2011). Here purification is not the only cause (agriculture weighs heavily), but it is part of the mosaic of pressures that determine eutrophication, loss of biodiversity, costs for purification, bans and loss of tourist attractiveness.

Finally, there is an often ignored cost: the waste of recoverable resources. Every cubic meter of purified water not reused, every ton of nutrients not recovered, every potential MWh not produced from biogas, is a double loss: because you give up a resource and continue to pay for alternative supplies.

The data reported in Table 3 show how failure to invest does not generate savings, but on the contrary produces certain and repeated costs. In addition to direct sanctions, much higher environmental and health costs are added, which burden the community and the most fragile territories in a widespread manner.

Table 3: Cost magnitudes

Cost item	Order of magnitude
EU fines already paid by Italy	> 200 millions €
Ongoing six-monthly penalties	> 30 millions € / semester
Reactive nitrogen damage in the EU	70–320 billion € / year
Non-compliant Italian agglomerations	> 900

Source: Own elaboration

Implications and Conclusions

If waste water purification is recognized as a productive investment, and no longer a mere expense item imposed by regulatory obligation, the structure of public policies undergoes a substantial transformation. The issue is not limited to formal compliance with the provisions or avoiding infringement procedures, but concerns the planning, selection and hierarchization criteria of environmental infrastructures. From this perspective, purification takes on a structural function within sustainable development strategies, with implications that go beyond the technical perimeter of the integrated water service.

The scale of the investments required excludes the effectiveness of episodic or reactive interventions. Policies based on urgency or decisional fragmentation do not make it possible to fill the accumulated infrastructural gap, nor to ensure stable quality standards over time. Therefore, multi-year planning is required based on priorities expressed in a transparent manner and on rigorous analytical tools, including cost-benefit analysis. This

methodology must include, in addition to construction and management costs, the monetary valorization of the environmental, health and economic benefits associated with the improvement of water quality, the reduction of public health risks and the recovery of resources. Estimates relating to investment needs at European level indicate that the financial sustainability of the sector can only be guaranteed through long-term strategies, capable of integrating environmental, climate and production objectives within a coherent development framework.

Alongside the financial dimension, the quality of governance and management capacity takes on importance. The fragmentation of management, still widespread in various areas of the national territory, is associated with a lower propensity to invest, operational inefficiencies and uneven service standards. The transformation of purification plants into integrated circular economy platforms requires specialized technical skills, industrial organizational models, advanced performance monitoring systems and an incentive-oriented regulatory structure. An effective regulatory framework does not limit itself to prescribing obligations, but introduces reward mechanisms for the recovery of material and energy, for energy efficiency and for technological innovation. In the absence of institutional and management strengthening, even large investments risk producing effects below potential, limited to the resolution of specific critical issues without affecting the structural determinants of the system.

The analysis takes on particular relevance on a territorial level, with reference to the South, where the infrastructural deficit in the purification sector has historically more marked characteristics. In these areas, the cost of inaction manifests itself through a plurality of channels: reiteration of European sanctioning procedures, deterioration of ecosystems, reduction of tourist attractiveness, constraints on agricultural development and worsening of the quality of life. The investment in purification is not configured as a mere response to a sanction, but as a structural intervention aimed at interrupting a circuit that links infrastructural deficiencies, economic penalties and low territorial competitiveness. The creation of efficient and technologically advanced systems can, on the contrary, constitute an enabling factor for local development, through the improvement of the quality of coastal and inland waters, support for tourism and agri-food chains and the reduction of historical inequalities between the different areas of the country.

Furthermore, wastewater purification must be classified as a strategic investment category, capable of generating environmental, health and economic returns and reducing the future vulnerabilities of the territories. In the presence of growing water stress and stringent ecological transition objectives, the qualification of wastewater as mere waste to be disposed of

appears economically inefficient and politically short-sighted. A different approach, based on planning, governance and sectoral integration, represents a necessary condition for combining environmental protection and development.

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