Supplementary Material

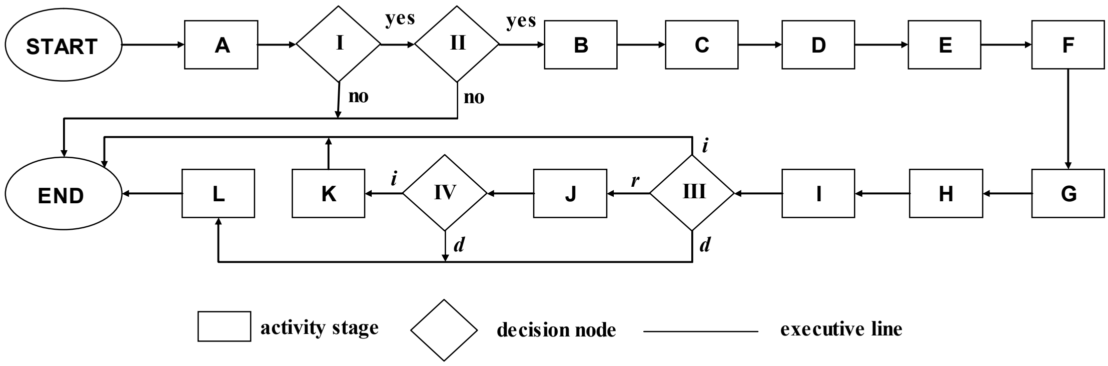

Fig. 1. The methodological framework, designed/developed by the authors under the form of an algorithmic procedure for developing novel adsorptive materials based on bio-waste recycling and processing.

Activities that take place within stage F (biomass processing), as shown in the network of Fig. 2.

Activity	Description
(1,2)	System (herein batch process) design.*
(1,3)	Determination of required specifications.
(2,4)	Tolerance design.*
(2,5)	Parameter design.*
(5,6)	Special mixing design.
(6,7)	Biomass transfer, weighting, milling.
(7,8)	Biomass mixing and storing.
(8,9)	Sampling, testing.
(9,10)	Selection of criteria for comparative evaluation of biomass modification methods.
(9,11)	Collection of biomass modification methods.
(11,12)	Evaluation of the elements of the multicriteria preference matrix.
(12,13)	Multicriteria analysis.
(13,14)	Design of batch experiments on kinetics/isotherms.
(14,15)	Performing of experimental work and processing of results for parameter-values estimation.
(15,16)	Design of experiments for estimating thermodynamic parameter-values.
(16,17)	Performing of experimental work and processing of results for parameter-values estimation.
(17,18)	Determination of required specifications.
(17,19)	Column process design.*
(19,20)	Tolerance design.*
(19,21)	Parameter design.*
(21,22)	Design of column experiments on kinetics and isotherms.
(22,23)	Performing of experimental work and processing of results for parameter-values estimation.
(23,24)	(Gray box) modeling by means of dimensional analysis.
(23,25)	(Black box) modeling by means of empirical techniques.
(23,26)	(White box) mechanismic modeling.

(26,27) Testing.
(27,28) Comparison.
(28,29) Meta-analysis based on a holistic approach to decide on the necessity of proceeding with a next/upper scale.

**in the sense of Taguchi terminology for quality engineering*

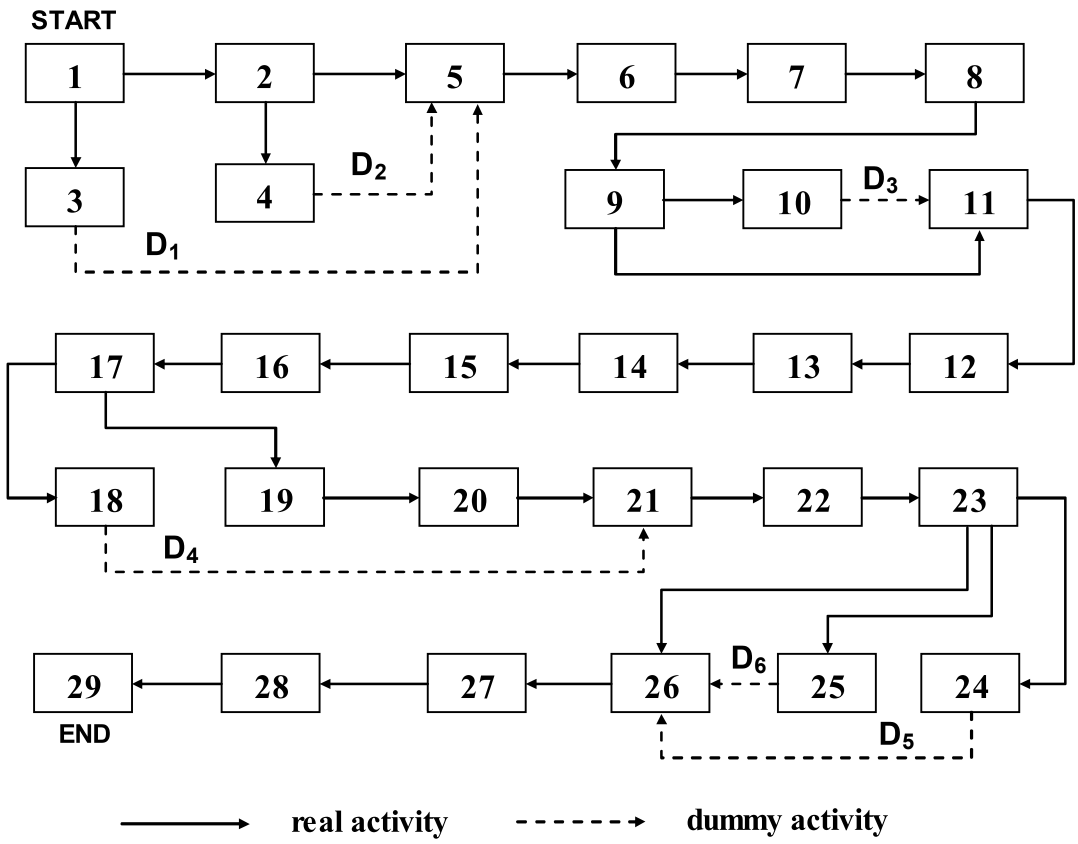

Fig. 2. Arrow/network diagram representing the activities that take place within stage (F), i.e., biomass processing, of a R&D project for developing novel adsorptive materials based on bio-waste recycling. Each arrow represents a unique activity with its head indicating the direction of progress of the project. Each event (boxed number) represents a point in time that signifies the completion of some activities and the beginning of new ones. The dummy activities, D_1, D_2, D_4, D_5, D_6, are used to establish correct precedence activities; D_3 is used to identify activities (namely, 'collection of biomass modification methods', 'selection of criteria for comparative evaluation of biomass modification methods') that have common start and end events.

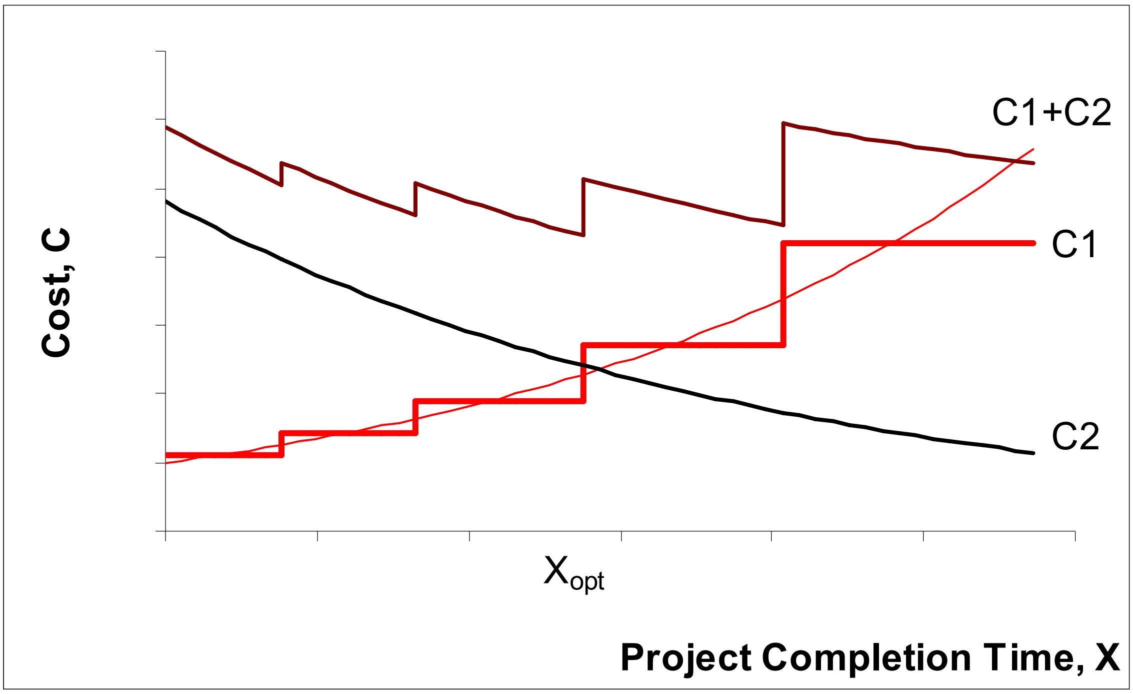

Fig. 3. The project completion time X (considered as the independent/stochastic variable) optimization is achieved by minimizing total cost C consisted of two conflict partial variables C_1 and C_2, representing cost of stage (F) and cost of the rest downstream stages, respectively: the higher the cost C_1, due to performing more scale-up effort, the lower the cost C_2, due to producing lower-cost of higher-quality product. X_{opt} is estimated at $C_{min}=(C_1+C_2)_{min}$ as an equilibrium point of this tradeoff, allowing for sensitivity/ robustness analysis to examine the influence/impact of endogenous and exogenous factors, like the accumulation of experience in the time course (known as 'learning by doing') and the increase of oil prices in the long run, respectively. C_1 a stepwise function, corresponding to five scale-up levels of experimentation: Lab, Bench, Pre-pilot, Pilot, Prototype.

Basic references for the project management part of the paper.

[1] G.E.P. Box, W.G. Hunter, J.S. Hunter, *Statistics for Experimenters,* John Wiley & Sons, New York, 1978, pp. 453-537.

[2] D.C. Montgomery, *Design and Analysis of Experiments,* 4th Ed., John Wiley & Sons, New York, 1997, pp. 622-641.

[3] H.A. Taha, *Operations Research,* 4th Ed., MacMillan Publ. Co., New York, 1982, pp. 469-501.