

Polytechnic University of the Philippines
Office of the Vice President for Research, Extension, and Development

Produced by:
Institute for Science and Technology Research

Cover Design & Layout by:
Jesusana S. Dejito

Technical Assistance by:
Publications Office

PUP Journal of Science and Technology

Volume 11, January to December 2018

Print ISSN-1908-9058

Online ISSN-2546-0749

Journal Description

The **PUP JOURNAL OF SCIENCE AND TECHNOLOGY (PUPJST)** is a CHED-accredited, double-blind, peer reviewed journal that publishes original articles on theoretical and applied studies in the field of science and technology. It is an annual research publication that aims to provide significant involvement of researchers by presenting novel ideas as well as new knowledge for the advancement of the society in general.

Focus and Scope of Journal

The **PUP JOURNAL OF SCIENCE AND TECHNOLOGY (PUPJST)** publishes original scientific papers and application-focused articles from recent accomplished researches on physical sciences, life sciences, food sciences, nutrition and dietetics, agricultural sciences, environmental sciences, computing and information sciences, mathematics, engineering and technology. The articles must pose valuable hypothesis to derive novel perspectives, verify scientific concepts and innovation in technological advances. The journal does not publish purely descriptive articles that descend from a well-documented exposition, short communication, survey or even a comprehensive review of currently active area of research.

EDITORIAL BOARD

Editor-in-Chief

Armin S. Coronado, *Polytechnic University of the Philippines*

Editorial Members

Dahlia C. Apodaca, *Mines and Geosciences Bureau, Philippines*

Jose Maria P. Balmaceda, *University of the Philippines - Diliman*

Argel A. Bandala, *De La Salle University*

Maribel L. Dionisio-Sese, *University of the Philippines – Los Baños*

Manuel M. Muhi, *Polytechnic University of the Philippines*

Reinabelle C. Reyes, *Ateneo de Manila University*

Jonathan Richir, *University of Mons, Belgium*

Aleta C. Fabregas, *Polytechnic University of the Philippines*

Managing Editors

Gary Antonio C. Lirio, *Polytechnic University of the Philippines*

Alexander S. Carrascal, *Polytechnic University of the Philippines*

Section Editors

Lincoln A. Bautista, *Polytechnic University of the Philippines*
Kennedy Bongon, *Polytechnic University of the Philippines*
Christian Jay B. Cambiador, *Polytechnic University of the Philippines*
Alexander S. Carrascal, *Polytechnic University of the Philippines*
Michael dela Fuente, *Polytechnic University of the Philippines*
Rogelio G. Dizon, *Polytechnic University of the Philippines*
Elvira C. Labartine, *Polytechnic University of the Philippines*
Esperanza S.J. Lorenzo, *Polytechnic University of the Philippines*
Ria A. Sagum, *Polytechnic University of the Philippines*
John Patrick Sta. Maria, *Polytechnic University of the Philippines*
Jackie B. Urrutia, *Polytechnic University of the Philippines*
Kristian Carlo B. Victorio, *Polytechnic University of the Philippines*

Reviewers

Akira Asakura, *Seto Marine Biological Laboratory (SMBL), Kyoto University, Japan*
Fernando B. Aurigue, *Philippine Nuclear Research Institute*
Melito A. Baccay, *Technological University of the Philippines*
Esperanza C. Cabrera, *De La Salle University*
Jeffrey C. De Vero, *National Institute of Advanced Industrial Science and Technology, Tsukuba, Ibaraki, Japan*
Cecil Jose A. Delfinado, *University of Santo Tomas*
Cynthia C. Divina, *Central Luzon State University*
Julieta Z. Dungca, *Centro Escolar University*
Ford Lumban Gaol, *Bina Nusantara University, Indonesia*
Armando Victor M. Guidote, *Ateneo de Manila University*
Richard N. Muallil, *Mindanao State University, Tawi-Tawi*
Veeranoot Nissapatorn, *University of Malaya, Malaysia*
Michael Y. Roleda, *Norwegian Institute of Bioeconomy Research, Norway*
Edison A. Roxas, *University of Santo Tomas*
Giovanni A. Tapang, *University of the Philippines – Diliman*
Ryan Rhay P. Vicerra, *University of Santo Tomas*
Gilbert U. Yu, *Ateneo de Manila University*