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Technology and Engineering

Research Methodology & Scientific Writing MOOC – Unite!Energy

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<https://scholar.google.com/citations?hl=pl&user=UEecLkwAAAAJ>

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ResearchGate:

<https://www.researchgate.net/profile/Izabela-Michalak>



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Lectures (L) / projects (P) in English:

- ☐ Agrochemicals and plant health products (L)
- ☐ Environment protection (L)
- ☐ Environment impact (L)
- ☐ Research methodology (P)
- ☐ The latest research directions in chemical engineering (L)

Courses in Polish:

- ☐ Ecotoxicology (LAB)
- ☐ Development trends in chemical technology (L)
- ☐ Statistical methods for the results evaluation (P)

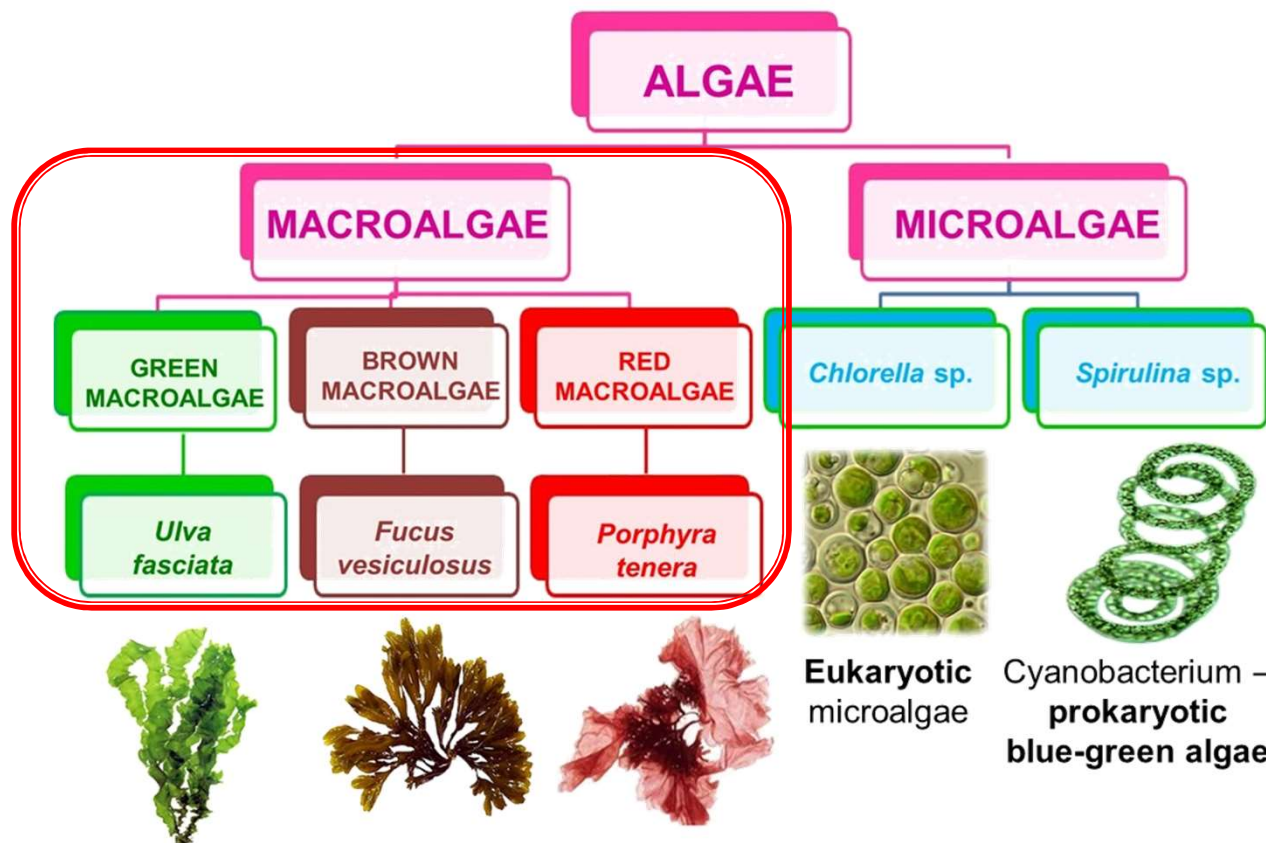
Supervisor of:

- ☐ Engineering students
- ☐ Master's students
- ☐ Erasmus students
- ☐ PhD students
- ☐ Interns



Scientist – my approach to research

SCIENTIST



Valorization of waste biomass
(especially **seaweed** biomass)
into valuable products for
modern agriculture
and **environmental protection**.

It is estimated that about **1800** different **brown macroalgae** (*Phaeophyceae*), **1800** **green macroalgae** (*Chlorophyceae*) and **6200** **red macroalgae** (*Rhodophyceae*) are found in the marine environment.

Sources of the algal biomass in Poland



- Large quantities mainly of green seaweeds, resulting from the **eutrophication**, are cast ashore on the beaches of Baltic Sea
- There is a necessity to collect this biomass and **dispose** in a **cost-effective** and **environmental-friendly method**

- Nowadays, macroalgae (**seaweeds** / **freshwater macroalgae**) used for **agriculture purposes** are mainly based on the collected **wild biomass**
- In some cases, this is a „**win-win solution**”



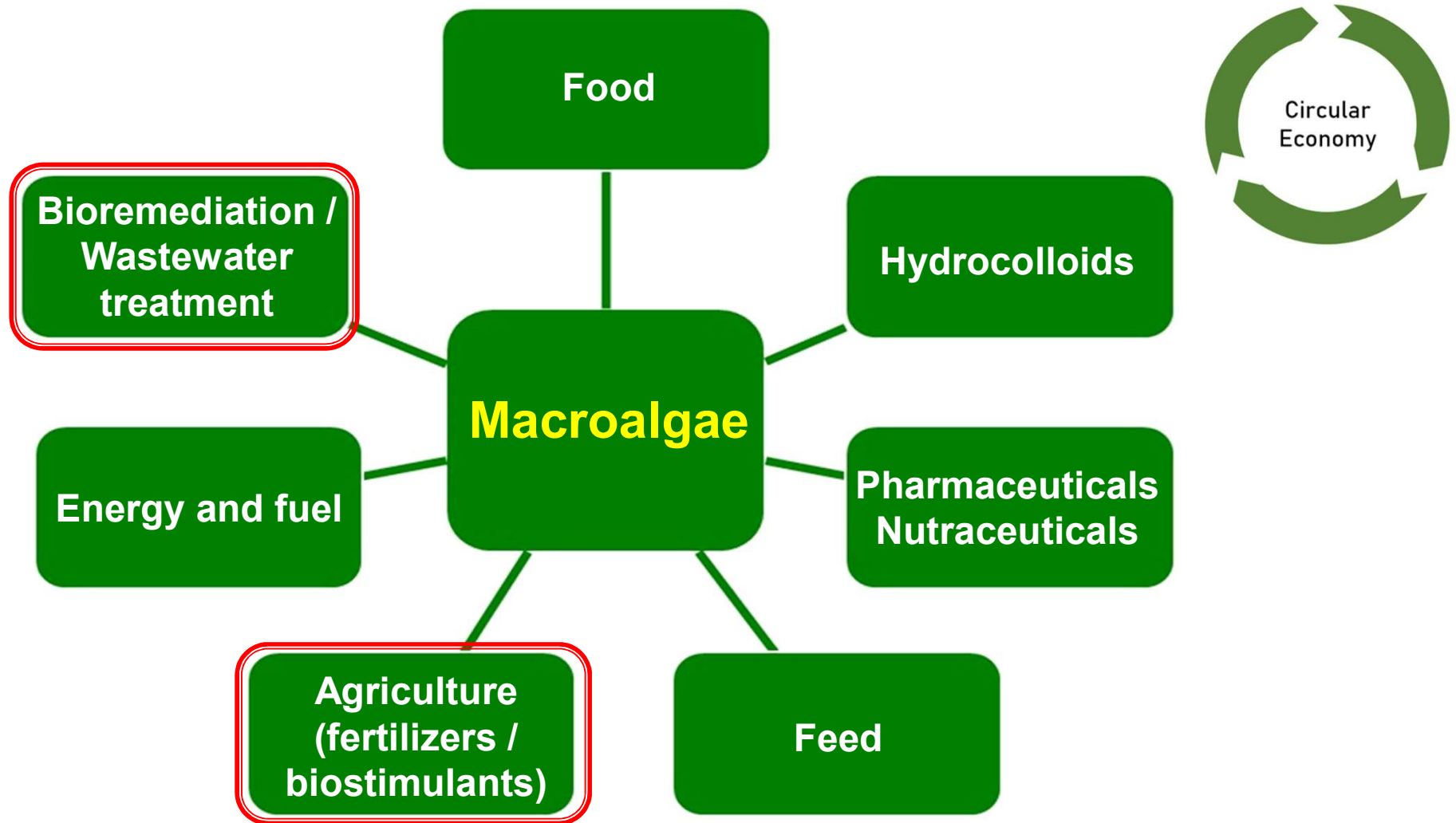
Waste macroalgal biomass – a global problem



Pedro Portal / Miami Herald

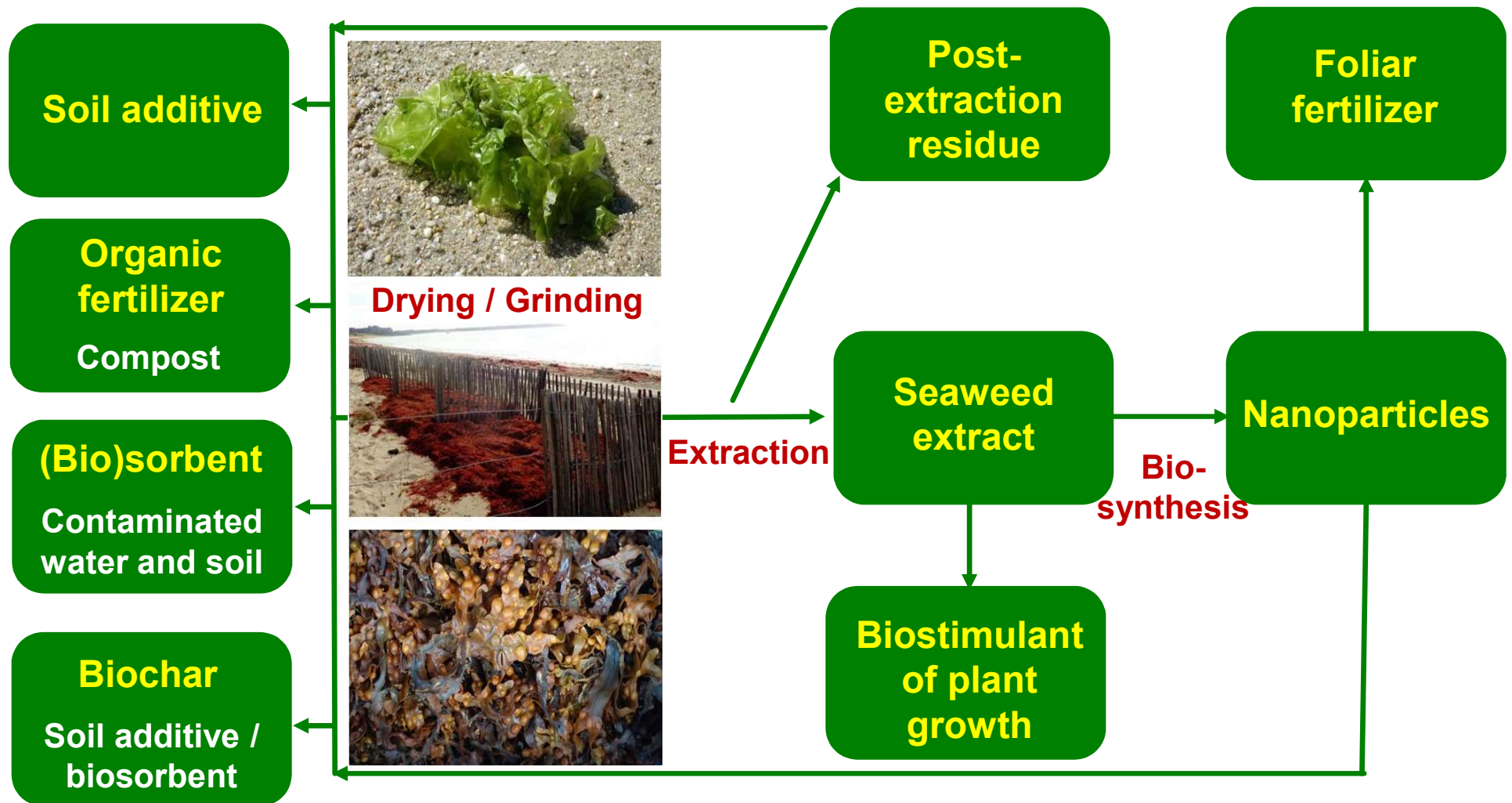
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Potential applications of macroalgae



My approach to research – methods of seaweed processing

You should like your research topic, then it becomes a passion !!!



Projects concerning algae / seaweed

Research topics are very important because they enable obtaining funding for research !!!

MNiSW
N N209 146136

Technology of feed additives from seaweeds enriched with microelements via biosorption and bioaccumulation method
(20.04.2009-26.02.2010)

NCN
2012/05/D/ST5/03379

Biologically active compounds in extracts from Baltic seaweeds
(04.02.2013-03.02.2016)

NCBiR
PBS/1/A1/2/2012

Innovative technology of seaweed extracts – components of fertilizers, feed and cosmetics
(11.11.2012-31.05.2016)

NCN
2015/18/E/NZ9/00607

The effect of bioactive algae enriched by biosorption on the certain minerals such as Cr(III), Mg(II) and Mn(II) on the status of glucose in the course of metabolic syndrome horses. Evaluation *in vitro* and *in vivo*
(01.04.2016-14.06.2021)

NCN
2019/33/B/NZ9/01844

Eco-friendly technologies for the management of seaweed biomass for products useful for sustainable agriculture and biosorbents used for the removal of heavy metal ions from the environment
(18.02.2020-17.02.2024)

Research Methodology & Scientific Writing MOOC – aim

Aim of the course:

unite!



1

How to plan research

2

How to present research methodology

3

How to prepare a thesis proposal /
How to effectively write a scientific paper

Research Methodology & Scientific Writing MOOC – conditions

Duration of classes:

- One hour = 45 min
- A break of 15 minutes should be taken after every 45 minutes

3-hours classes (90 min + 45 min):

9:00-9:45-10:30 → 15 minutes break → 10:45-11:30

2-hours classes (90 min):

9:00-9:45-10:30

Research Methodology & Scientific Writing MOOC – content

Research process – Step 1

1. Formulating the research problem / Identifying a research topic
2. Finding background information / Extensive literature survey (systematic tracking of scientific literature; creating search queries; current databases – Web of Knowledge, Scopus, Google Scholar, etc.)
3. Developing the research hypothesis
4. Preparing the research design (approach / methodology)
5. Collecting the research data / Variables and their types (basic elements of statistical analysis)
6. Analysis of data
7. Hypothesis testing
8. Interpretation of data / Findings and drawing conclusions



BRIDGE CENTER

RESEARCH METHODOLOGY: TOOLS AND TECHNIQUES

Dr. Prabhat Pandey

Dr. Meenu Mishra Pandey

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Research Methodology & Scientific Writing MOOC – content

Research process – Step 2

1. Methods of presenting results (figures, tables, drawings, photos, etc.)
2. Preparing of the report / thesis
3. Writing of scientific publication:
 - Discussion of the structure of a research publication (Instructions for authors) / Different publication templates depending on the publisher
 - Abstract writing strategies / Preparing a graphic abstract
 - Preparing a Cover Letter
 - Discussing the publication submission system / Selecting the most appropriate journal
 - Corresponding with editors and responding to questions from reviewers and the editor

Assessment – Final report

Report – Research Methodology & Scientific Writing MOOC – Unite!Energy

1. Name and surname
2. E-mail address
3. University name
4. Scientific profiles – if applicable
5. PhD title / Proposed PhD title
6. Summary of planned research (500 words)
7. Graphical abstract presenting the topic of the PhD thesis
8. Keywords (5-7)
9. What is the research hypothesis put forward in the doctoral dissertation?
10. What is (or could be) the „bottleneck” in your research and why?
11. List of 3-5 best journals in the research area of the doctoral dissertation (e.g., with the highest Impact Factor and Category quartile, briefly justify)
12. List of the 5-10 best scientific papers in the research area of the doctoral dissertation (number of citations)
13. The best scientific publication you have read so far and motivate shortly your choice
14. The worst scientific publication you have read so far and motivate shortly your choice
15. List 3 patents (patent number) that are similar to the topic of the doctoral dissertation
16. Data on the researchers (2-3) and their affiliations where would you like to do an internship (briefly justify)

Deadline: 31 October 2025 ➡ E-mail: izabela.michalak@pwr.edu.pl



Research methods vs. Research methodology

Research Methods

Behaviors and instruments used in the selection and construction of the research technique



VS

Research Methodology

Science of understanding how research is performed methodically



Source: Surbhi, 2016

Guide2Research

Research methods may be understood as all methods / techniques that are used for conduction of research.

Research methodology is a way to systematically solve the **research problem**

Formulating the research problem / Identifying a research topic

- ❑ The researcher must decide the **general area of interest** or **aspect of a subject matter** that he would like to inquire into and then research problem should be formulated.
 - The **innovativeness of research** should be pointed out
 - A **gap in scientific research** should be pointed out
 - If you are solving an existing problem, you should show the advantages of your solution /method / approach in comparison to previous works of other researchers
- ❑ Once the problem is formulated the researcher should undertake **extensive literature survey** connected with the problem and **patent database review** – „patent purity”
- ❑ **The literature search in databases should result in the collection of valuable publications (pdf files) of high scientific quality.**



Then, the source of publications related to the research topic we are dealing with may be **citations / references** in these publications.

„References” section in publications

scientific reports

OPEN

Brown seaweed: *Fucus vesiculosus* as a feedstock for agriculture and environment protection

Karolina Krautforst¹, Anna Szymczycha-Madeja², Maja Welna² & Izabela Michalak^{1,3}



References

1. Chojnacka, K. *et al.* Algal extracts as plant growth biostimulants. In *Marine algae extracts: Processes, products, and applications* Vol. 11 (eds Kim, S. K. & Chojnacka, K.) 189–212 (Wiley-VCH Verlag GmbH & Co. KGaA, 2015).
2. Żurek, G. Alternative plants for phytoextraction of heavy metals from contaminated areas. *Prob Inż. Rol.* 3, 83–89 (2009).
3. Savci, S. Investigation of effect of chemical fertilizers on environment. *APCBEE Proc.* 1, 287–292 (2012).
4. Bikovens, O. *et al.* Development of the approaches for complex utilization of brown algae (*Fucus vesiculosus*) biomass for the obtaining of value-added products. 8th International Scientific Conference Rural Development 222–225 (2017).
5. Peng, Y. *et al.* Chemical composition of seaweeds. *Seaweed Sustain.* 5, 79–124 (2015).
6. Balina, K., Romagnoli, F. & Blumberga, D. Chemical composition and potential use of *Fucus vesiculosus* from Gulf of Riga. *Energy Procedia* 95, 43–49 (2015).
7. Catarino, M. D., Silva, A. & Cardoso, S. M. Phytochemical constituents and biological activities of *Fucus* spp. *Mar. Drugs* 16(8), 249 (2018).
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9. Jimenez-Lopez, C. *et al.* Main bioactive phenolic compounds in marine algae and their mechanisms of action supporting potential health benefits. *Food Chem.* 341, 128262 (2020).
10. Mzibra, A. *et al.* Biostimulants derived from Moroccan seaweeds: Seed germination metabolomics and growth promotion of tomato plant. *J. Plant Growth Regul.* 40, 353–370 (2021).
11. Abd-Elhady, E. S. E. Evaluation of algae dry biomass as a biochemical soil remediation for polluted soil. *Int. J. Environ.* 4(4), 309–314 (2015).
12. Abd-Elhady, E. S. E. & El-Zabalawy, K. M. Remediation of a soil contaminated with heavy metals using some seaweeds. *J. Soil Sci. Agricult. Eng.* 5(12), 1623–1633 (2014).
13. Ahmed, D. A. E. A., Gheda, S. F. & Ismail, G. A. Efficacy of two seaweeds dry mass in bioremediation of heavy metal polluted soil and growth of radish (*Raphanus sativus* L.) plant. *Environ. Sci. Pollut. Res.* 28, 12831–12846 (2021).
14. Michalak, I. The application of seaweeds in environmental biotechnology. *Adv. Bot. Res.* 95, 85–111 (2020).

General note:

When citing publications / book chapters, regardless of the type of work (publication, doctoral thesis, report, etc.), the **citation style should be unified**.

Patent database – Polish Patent Office

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WYSZUKIWARKA PROSTA

Kryteria wyszukiwania

Wyszukiwanie: biostimula

WYSZUKIWARKA ZAAWANSOWANA

Uwzględnij polskie znaki

SZUKAJ

Rodzaje PWP



PAT: Biostymulator wzrostu roślin (Plant growth biostimulant – Polish patent)



Numer zgłoszenia	Application number	P.412074	Numer prawa wyłącznego	Pat.230687		
Data zgłoszenia	Application date	2015-04-20	Status ⓘ	Current status	Prawo w mocy	Valid
Nazwa/Tytuł	Application title	Biostymulator wzrostu roślin	Zgłaszający/Uprawniony	Applicant	UNIwersytet OPOLSKI, Opole, PL, POLITECHNIKA WROCŁAWSKA, Wrocław, PL, UNIwersytet IM. ADAMA...	

Skrót opisu - tekst (Short description)

Wynalazek dotyczy biostymulatora wzrostu roślin przeznaczonego do zwiększania wydajności plonowania, zawierającego od 0,1 do 60% masowych nadkrytycznego ekstraktu z biomasy alg, wybranych z grupy obejmującej mikroalgi, korzystnie Spirulina species i makroalgi, korzystnie Fucus species oraz makroalgi bałtyckie z rodzaju Cladophora i Enteromorpha, uzyskanego przy użyciu ekstrahenta w postaci nadkrytycznego ditlenku węgla (CO₂). Ponadto biostymulator wzrostu roślin zawiera od 0,1 do 60% masowych emulgatora, wybranego z grupy obejmującej jonowe, niejonowe i amfoteryczne środki powierzchniowo czynne oraz od 5 do 95% masowych wody. Ujawniono również sposób wytwarzania biostymulatora wzrostu roślin, który polega na tym, że rozdrobnioną biomase alg, ekstrahuje się nadkrytycznym ditlenkiem węgla, w temperaturze od 35°C do 70°C, pod ciśnieniem od 300 do 1000 bar, z zachowaniem proporcji ekstrahenta do surowca, w granicach od 30 do 80 kg CO₂ na 1 kg biomasy. Ekstrakt miesza się z emulgatorem w proporcji od 1 : 99, wybranym z grupy obejmującej jonowe, niejonowe i amfoteryczne środki powierzchniowo czynne, a następnie miesza się z wodą, w takiej proporcji, aby udział ekstraktu algowego w całkowitej masie biostymulatora wynosił od 0,1 do 60%. Korzystnie przed procesem ekstrakcji, biomase alg kondycjonuje się w roztworze kwasu nieorganicznego i/lub poddaje się działaniu ultradźwięków lub mikrofal.



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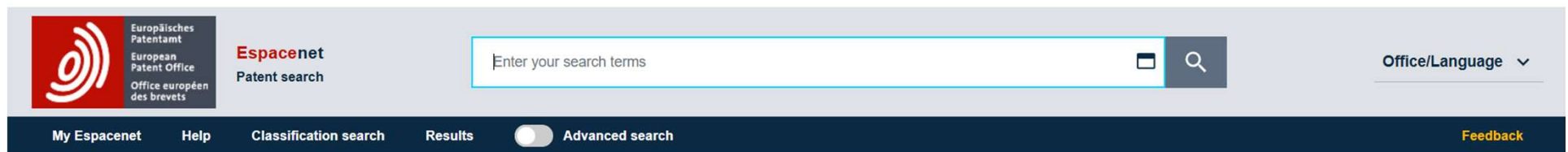

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- ❑ **PATENTSCOPE** – an international database of patent documents maintained by WIPO (World Intellectual Property Organization, an organization established under the Stockholm Convention in 1967 to promote industrial and intellectual property matters): <https://www.wipo.int/en/web/patentscope>
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- ❑ **USPTO** – an international database of patent documents maintained by United States Patent and Trademark Office: <https://www.uspto.gov/patents/search/patent-public-search>



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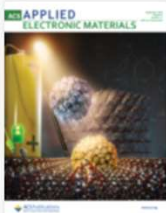
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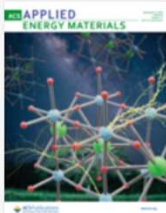
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are papers published in the last two years that are receiving citations quickly after publication.

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Production of biochar aggregate particles used for industrial applications e.g. agriculture and composting, involves collecting biochar fines, adding binding agent to fines and forming fines and agent into solid aggregate particles

US2017197192-A1; US10322389-B2

Inventors : MALYALA R; TRAXLER V; (...); BELCHER R W

Assignee : COOL PLANET ENERGY SYSTEMS INC

Derwent Primary Accession Number : 2017-478564

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By

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A comprehensive review of engineered biochar: Production, characteristics, and environmental applications

 Highly Cited Paper

Name and surname – **full and short version** – this is the correct version (sometimes it is difficult to distinguish which is the name and which is the surname, and errors occur in citations of publications)



By



Michalak I. / Izabela M.

Panahi, HKS (Panahi, Hamed Kazemi Shariat) ^{[1], [2], [3]}; Dehhaghi, M (Dehhaghi, Mona) ^{[1], [2], [3]}; Ok, YS (Ok, Yong Sik) ^{[4], [5]}; Nizami, AS (Nizami, Abdul-Sattar) ^[6]; Khoshnevisan, B (Khoshnevisan, Benyamin) ^[7]; Mussatto, SI (Mussatto, Solange I.) ^[8]; Aghbashlo, M (Aghbashlo, Mortaza) ^[9]; Tabatabaei, M (Tabatabaei, Meisam) ^{[1], [3], [10], [11]}; Lam, SS (Lam, Su Shiung) ^{[1], [12], [13]}

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Source

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Publisher name: ELSEVIER SCI LTD

Journal Impact Factor TM

10

2024

10.7

Five Year

JCR Category	Category Rank	Category Quartile
ENGINEERING, ENVIRONMENTAL <i>in SCIE edition</i>	9/83	Q1
ENVIRONMENTAL SCIENCES <i>in SCIE edition</i>	23/374	Q1
GREEN & SUSTAINABLE SCIENCE & TECHNOLOGY <i>in SCIE edition</i>	12/102	Q1

Example Calculation of an Impact Factor for 2009:

Cites in 2009 to articles published in:

- 2008 = 9000
- 2007 = 8000

Total recent citations in 2009 = 17000

Number of items published in:

- 2008 = 1500
- 2007 = 1200

Total number of recent items published = 2700

Impact Factor:

$$\frac{\text{Cites to recent item}}{\text{No. recent items}} = \frac{17000}{2700} = 6.296$$

The **Journal Impact Factor** – is a metric developed by Clarivate Analytics to measure a journal's relative importance within its field.

Q1, Q2, Q3, Q4: Quartiles of scientific journals

Q1	$0.0 < Z \leq 0.25$	Highest ranked journals in a category
Q2	$0.25 < Z \leq 0.5$	
Q3	$0.5 < Z \leq 0.75$	
Q4	$0.75 < Z$	Lowest ranked journals in a category

Z is defined as $Z = X / Y$

where:

X – is the journal rank in category

Y – is the number of journals in the category



Example when Journals are sorted by impact factor:

If a Journal is rank 78 out of 314 in a category, then:

$Z = 78 / 314 = 0.248$ which is a **Q1 journal**

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- ☐ Wang S 18
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- ☐ Liu Y 13
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- ☐ 51 [Web of Science Core Collection](#)
Seaweed for climate mitigation, wastewater treatment, bioenergy, bioplastic, biochar, food, pharmaceuticals, and cosmetics: a review

Farghali, M; Mohamed, IMA; (...); Rooney, DW

Feb 2023 | ENVIRONMENTAL CHEMISTRY LETTERS 21 (1), pp.97-152

The development and recycling of biomass production can partly solve issues of energy, climate change, population growth, food and feed shortages, and environmental pollution. For instance, the use of seaweeds as feedstocks can reduce our reliance on fossil fuel resources, ensure the synthesis of cost-effective and eco-friendly products and biofuel ... [Show more](#)

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Gaseous mercury capture using seaweed biochars modified by clean ultraviolet/hydrogen peroxide advanced oxidation process

Yang, W; Dou, ZF; (...); Huang, RK

Feb 20 2023 | JOURNAL OF CLEANER PRODUCTION 389

Seaweed-based biochars stemmed from the solid wastes of seaweed-based biomass pyrolysis were used to reduce the emission of elemental mercury. An environmentally-friendly ultraviolet/hydrogen peroxide advanced oxidation process modification method was used to increase the active species over seaweed-based biochars for elemental mercury ... [Show more](#)

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Enhanced copper (II) bioremediation from wastewater using nano magnetite (Fe₃O₄) modified biochar of *Ascophyllum nodosum*

Kumar, P; Patel, AK; (...); Dong, CD

Nov 2023 | BIORESOURCE TECHNOLOGY 388

Despite the remarkable Cu(II) sorption biochar potential, it is challenging to desorb them for repeated biochar usage. The present study aims to develop engineered biochar by polarizing *Ascophyllum nodosum* (seaweed) biomass and magnetizing it with Fe₃O₄ nanoparticles coating. SEM, EDX, XRD, BET, and FT-IR helped to characterize engineered ... [Show more](#)

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Feasibility of Biochar from Seaweed for Ferroalloy Production

Senanu, S; Sandquist, J; (...); Windfeldt, M

Sep 2024 | JOURNAL OF SUSTAINABLE METALLURGY 10 (3), pp.1380-1392

Biochar from seaweed, specifically sugar kelp, cultivated on the Norwegian coastline has been investigated as a possible biocarbon source for the metal industry to reduce the dependency on terrestrial biomass. Pre-processing of the biomass prior to pyrolysis is needed to reduce the water and ash content and was performed by water and acid wash ... [Show more](#)

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Web of Science – examples with the year of publication

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Checking how the number of publications on a given topic increases over the years.

Web of Science – examples with the year of publication

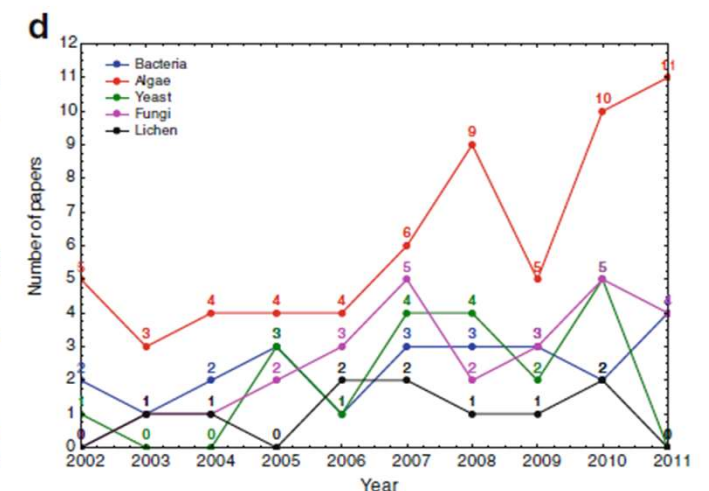
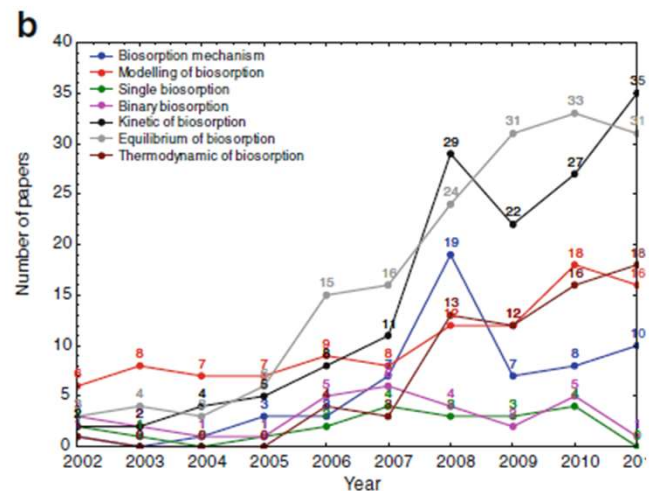
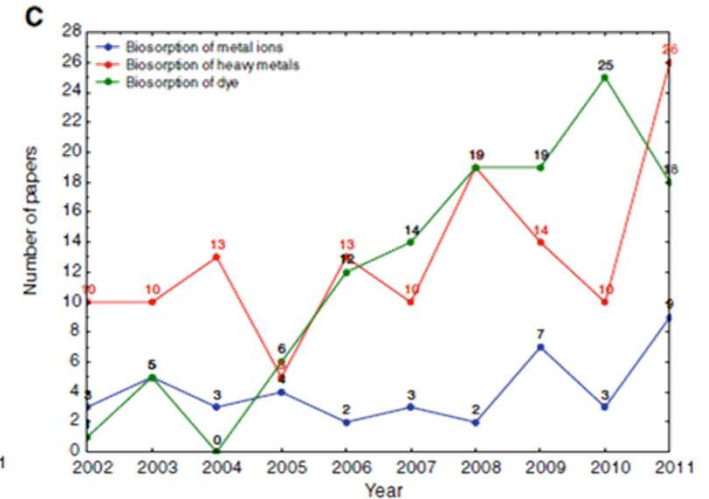
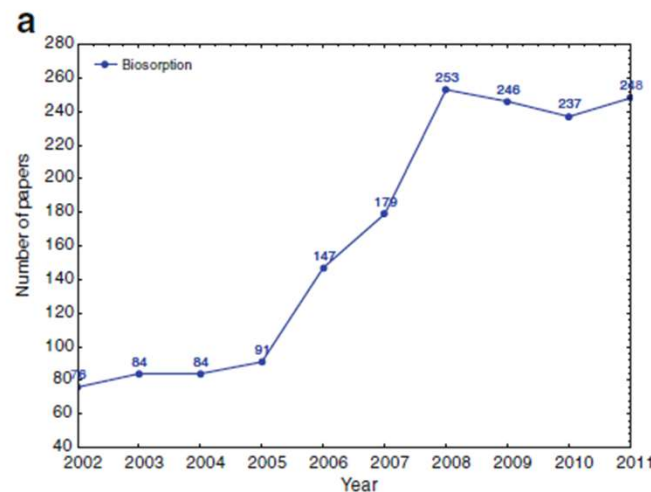
Number of papers on
biosorption with:

a “biosorption” word in
the topic of publication

b different “key words” in
the topic

c different “key words” in
the topic: type of sorbate

d different “key words” in
the topic: type of
biosorbent



Web of Science – example

Figure 1 presents several articles that concern the potential application of seaweed biochar in different areas.

For this purpose, the following keywords regarding **the topic of the publication** were searched in the **Web of Science database**:

“seaweed biochar” and – “soil amelioration”

“seaweed biochar” and – “wastewater remediation”

“seaweed biochar” and – “soil remediation”

“seaweed biochar” and – “carbon sequestration”

“seaweed biochar” and – “catalyst”

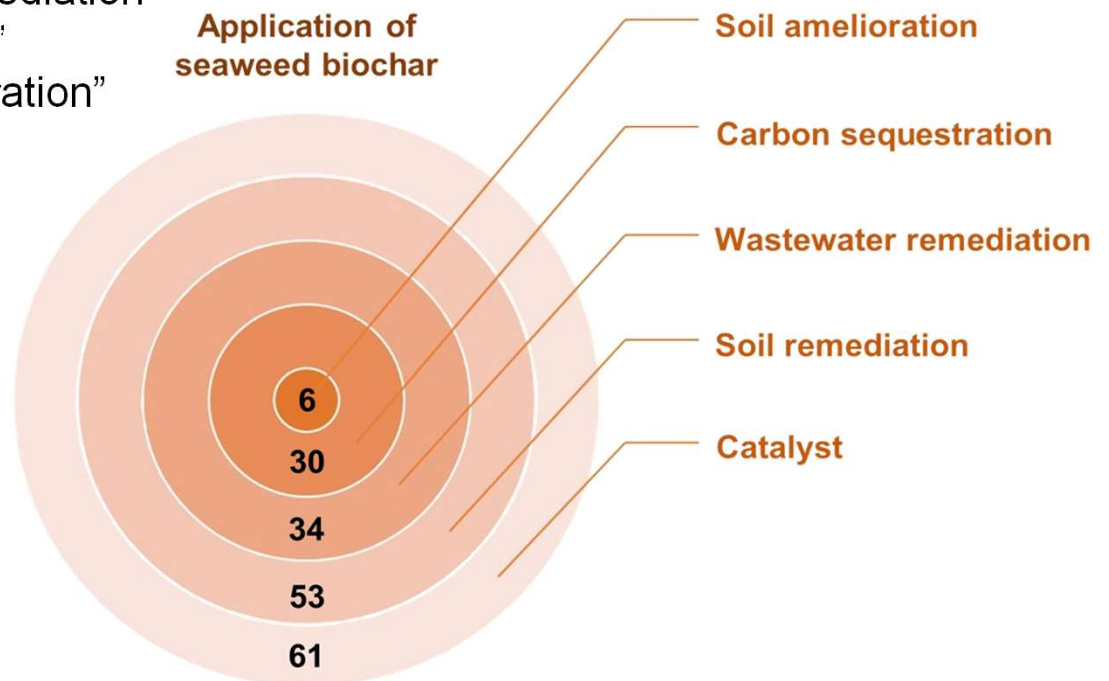


Figure 1. The number of publications that concerned potential applications of seaweed biochar (own source; according to the Web of Science database, 7 March 2025)

Web of Science – example

Seaweed biomass is very popular for removing heavy metal ions from wastewater.

Figure 2 presents the number of publications, concerning the biosorption of heavy metal ions by seaweed.

For this purpose, the following keywords were searched in the Web of Science database on **the topic of the publication**:

“biosorption by seaweed” and “coper”;

“biosorption by seaweed” and “cadmium”, etc.

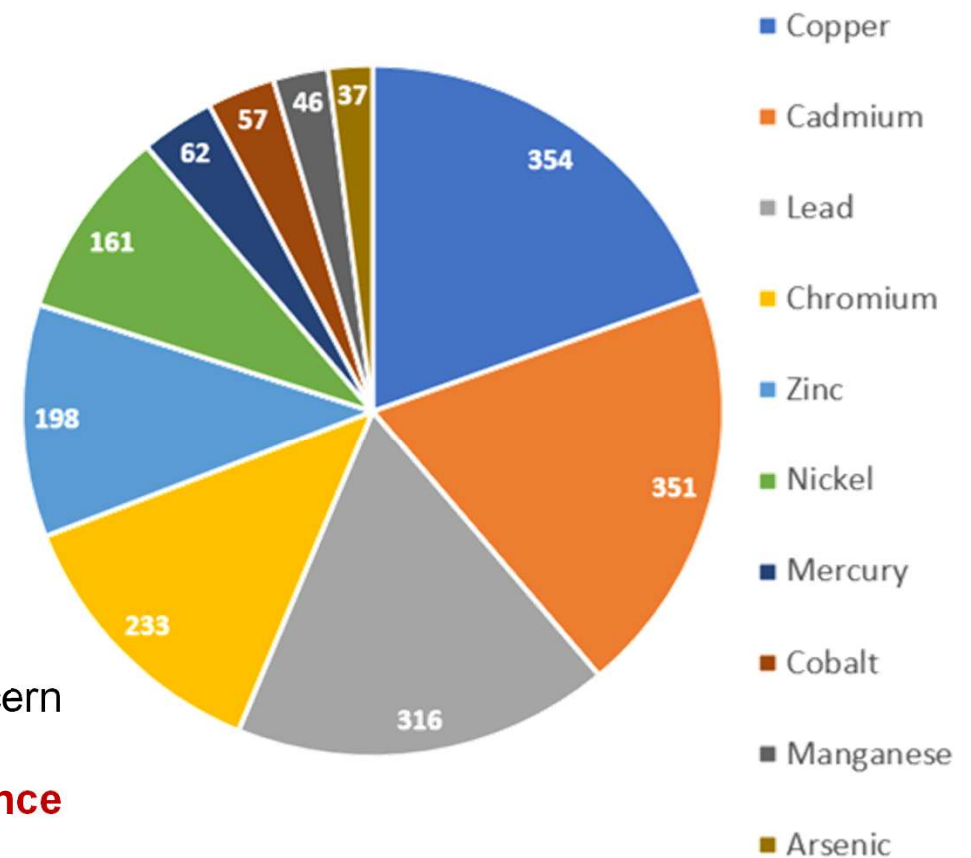


Figure 2. The number of publications that concern potential applications of seaweed biochar
(own source; according to the Web of Science database, 11 March 2025)

Scopus database

A very important database – when assessing the **scientific achievements of scientists**, data from this database is often taken into account – it is worth being registered here. Author indicators are higher in the Scopus database than in the Web of Science database because it also includes **book chapters**.

The ***h-index*** is a quantitative metric based on analysis of publication data using **publications** and **citations** to provide “an estimate of the importance, significance, and broad impact of a scientist’s cumulative research contributions.”

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Review • Open access

Phycobiostimulants: Next-Generation Sustainable Agricultural Inputs

Shukla, P.S., Michalak, I., Burlot, A.-S., ... Hurtado, A., Critchley, A.T.

ACS Agricultural Science and Technology, 2025, 5(4), pp. 424–453

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Article • Open access

Application of enzyme-assisted extraction on the brown seaweed *Fucus vesiculosus* Linnaeus (Ochrophyta, Fucaceae) to produce extracts for a sustainable agriculture

Choulot, M., Jabbour, C., Burlot, A.-S., ... Michalak, I., Bourgougnon, N.

Journal of Applied Phycology, 2025, 37(2), pp. 1325–1340, 100065

Document & citation trends

Citation overview Analyze author output

An ***h-index*** of 10 means that among all publications by one author, 10 of these publications have received at least 10 citations each.

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Authors search for Izabela Michalak

The **ORCID number** is crucial as it allows for distinguishing authors with the same name and surname.

It's worth registering to have your own number

Waste and Biomass Valorization
<https://doi.org/10.1007/s12649-025-02970-5>

ORIGINAL PAPER



Sustainable Applications of *Cladophora glomerata* Hydrolysates: *Nostoc commune* Cultivation and Utilizing Biowaste for Agricultural and Environmental Purposes

Elia Lio¹ · Katarzyna Łukowiak² · Martina Dramis¹ · Natalia Niedzbała² · Gianluca Ottolina¹ · Francesco Secundo¹ · Izabela Michalak²  ➡ ORCID number – once you click, you will be redirected to the ORCID database

Received: 14 September 2024 / Accepted: 8 February 2025
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Abstract

The green macroalga *Cladophora glomerata*, a species commonly infesting surface waters, was hydrolyzed by Liquid Hot Water treatment under acidic, neutral, and alkaline conditions. The liquid fraction obtained after hydrolysis was added to BG11 medium to cultivate the valuable cyanobacterium *Nostoc commune* under mixotrophic conditions, while the insoluble fraction was tested as a biosorbent of metal ions. In addition, cyanobacteria were grown under autotrophic conditions also in the presence of ZnO nanoparticles, biosynthesized using aqueous *C. glomerata* extract. Mixotrophic conditions with the use of acidic and alkaline algal hydrolysates produced the largest amount of *N. commune*. The post-culture media after *N. commune* separation were tested as potential biostimulants of plant growth, while the alga itself and the solid residue after hydrolysis were tested for the biosorption capacity of Cr(III) ions. The study presents an environmentally friendly method to transform the waste algal biomass into beneficial products for agriculture and the environment.

Keywords *Cladophora glomerata* · Thermal hydrolysis · *Nostoc commune* · Germination tests · Biosorption

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Activities

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Wroclaw University of Science and Technology: Wroclaw, PL

2010-02-22 to present | Associate Professor (Department of Advanced Material Technologies, Faculty of Chemistry) [Show more detail](#)
Employment

Source: ⓘ Izabela Michalak

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▼ Funding (5)

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Valorization of the waste macroalgae biomass into bio-products useful for sustainable agriculture and environment

2022-01 to 2023-12 | Grant
Narodowa Agencja Wymiany Akademickiej (Warsaw, PL)
GRANT_NUMBER: PPN/BIT/2021/1/00004/U/00001

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Source:  Izabela Michalak

Biomass valorization to enhance efficiency of toxic metals bioremediation from military and industry areas

2021-12 to 2024-12 | Grant
Organisation for the Prohibition of Chemical Weapons (The Hague, NL)
GRANT_NUMBER: L/ICA/ICB-105/21

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Source:  Izabela Michalak

Eco-friendly technologies for the management of seaweed biomass for products useful for sustainable agriculture and biosorbents used for the removal of heavy metal ions from the environment

2020-02 to 2024-02 | Grant
The National Science Centre in Poland (Cracow, PL)
GRANT_NUMBER: 2019/33/B/NZ9/01844

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ORCID account – publications / book chapters

Publication ➡

Publication ➡

Book chapter ➡

Works (50 of 146)		Sort
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Phycobiostimulants: Next-Generation Sustainable Agricultural Inputs		
ACS Agricultural Science & Technology 2025-04-21 Journal article DOI: 10.1021/acsagscitech.4c00777 CONTRIBUTORS: Pushp Sheel Shukla; Izabela Michalak; Anne-Sophie Burlot; Nathalie Bourgougnon; Bruno Daridon; Domenico Ronga; Anicia Hurtado; Alan T. Critchley		Show more detail
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Sustainable Applications of Cladophora glomerata Hydrolysates: Nostoc commune Cultivation and Utilizing Biowaste for Agricultural and Environmental Purposes		
Waste and Biomass Valorization 2025-03-07 Journal article DOI: 10.1007/s12649-025-02970-5 CONTRIBUTORS: Elia Lio; Katarzyna Łukowiak; Martina Dramis; Natalia Niedzbala; Gianluca Ottolina; Francesco Secundo; Izabela Michalak		Show more detail
Source:  Crossref		
Removal of elements of agricultural importance from wastewater by biochar and its subsequent use in agricultural crop production		
2024 Book chapter DOI: 10.1016/B978-0-443-21610-7.00012-4 CONTRIBUTORS: Natalia Niedzbala; Izabela Michalak		Show more detail
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Wrocław, Poland
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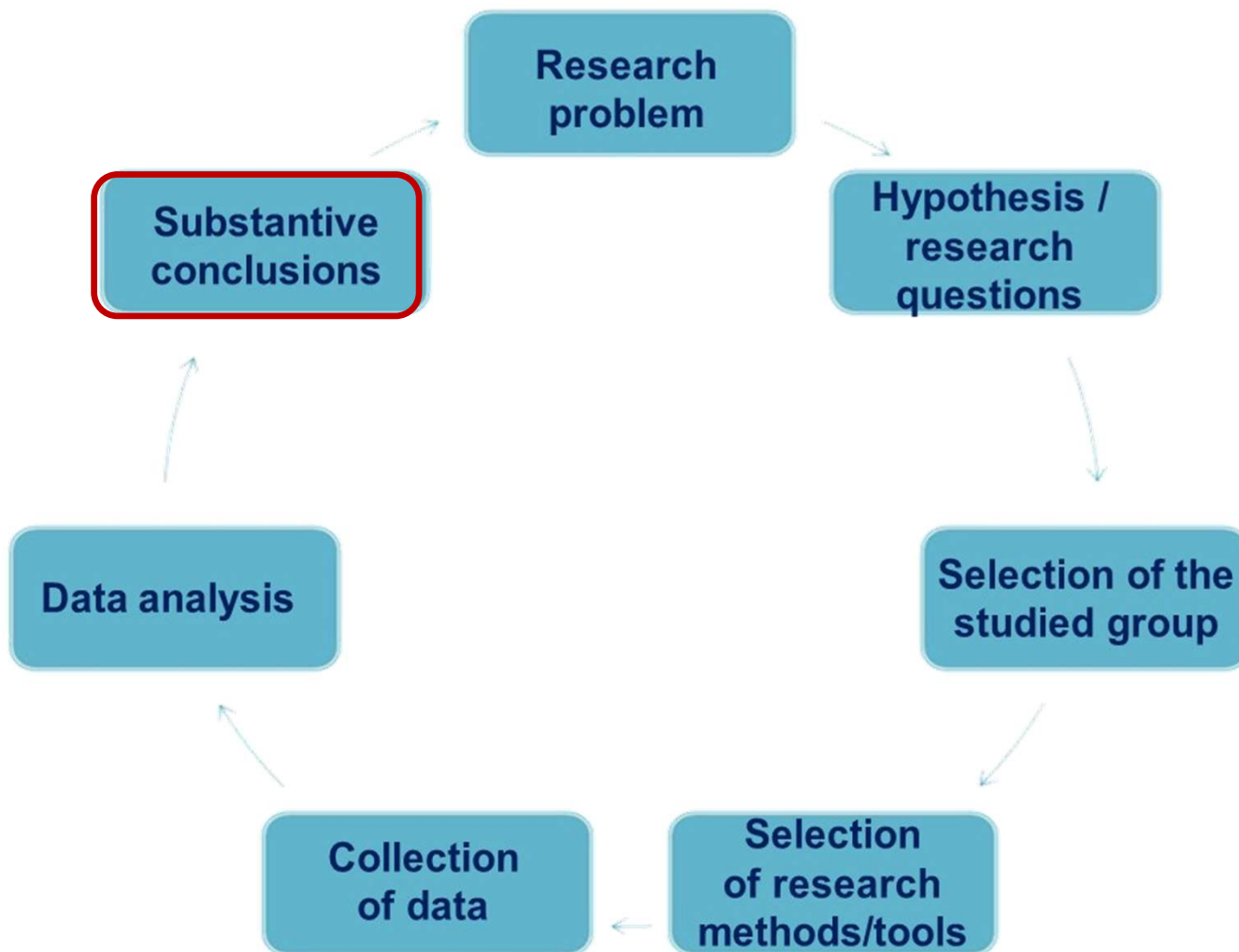
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You can easily ask for a publication

Benefits of a good literature review

- ❑ it is worth spending time reviewing publications related to a given research topic (**do it yourself**)
- ❑ you will become familiar with the **structure of a scientific publication** and **scientific language**
- ❑ you should be critical of the publications you read – unfortunately, due to the number of publications currently published, there may be publications of poor scientific quality (**quantity vs. quality**)
- ❑ publications (Materials and Methods section) may describe the use of **new research techniques** that you do not have in your laboratory, but may be useful in solving your research problem – this may be a **motivation to start new scientific cooperation**
- ❑ pay attention to the **authors of the publications** and their scientific achievements – they may be **potential reviewers of your publications** (when submitting a publication to a journal, you should usually suggest several reviewers, but this does not mean that they will be selected)
- ❑ pay attention to the **affiliation of the authors** of the publication – which research unit deals with a given topic – this may be a potential **place for a research internship** (after obtaining funding)

General scheme of the research process



A **statistical hypothesis**

—

is an assumption about a population parameter.

A **parameter** is a measurable characteristic of a population.

This assumption may or may not be true.

Developing the research hypothesis

After extensive literature survey, researcher should state in clear terms **the hypothesis / hypotheses** or **research questions**.

❑ In some disciplines, the hypothesis is called a “**thesis statement**”



Example: The addition of biochar to the soil increases wheat yield compared to soil without biochar.



Example: Will the addition of biochar to the soil increase wheat yield compared to soil without biochar?

❑ If a hypothesis is put forward in the prepared study, at the end of this study there should be a **verification of this hypothesis** – whether it has been confirmed / accepted or rejected.

Preparing the Research design

Research design is the framework of **research methods** and **techniques** chosen by a researcher.

- ❑ Good research design enables you to obtain appropriate evidence to address the research problem effectively.

Research methods are systematic processes / strategies and techniques (instruments – measurements) for **collecting** and **analyzing data** to answer research questions and test hypotheses.

They are categorized broadly into:

- ❑ **quantitative** (using numerical data and statistics),
- ❑ **qualitative** (focusing on descriptive, non-numerical data),
- ❑ and mixed methods (combining both).

Common **quantitative methods** often **involve experiments, surveys**, and **qualitative methods** include interviews, focus groups, case studies, and observation.

Preparing the Research design

Quantitative research approach – gathers numerical data:

- ☐ Data collected is numerical
- ☐ Data is analysed and converted into statistics
- ☐ Sample sizes should be quite large (to ensure that the differences for the measured parameter between the study groups are statistically significant)

Statistical data analysis – deals with methods of description and analysis of numerical regularities occurring in **mass phenomena (processes)**.

- ☐ We deal with mass phenomena when a sufficiently large number of units is examined → only then can certain regularities be observed.
- ☐ They cannot be detected by observing a single unit or a small set of units.

Examples of mass phenomena:

- ☐ **Demographic phenomena** (e.g., births, marriages, deaths)
- ☐ **Cases of illness** in medicine
- ☐ **Phenomena in industry and transport** (e.g., production of various articles, passenger transport)
- ☐ **Phenomena on the financial markets** (e.g., loan volume, stock prices on the stock exchange)

Quantitative research approach

POPULATION

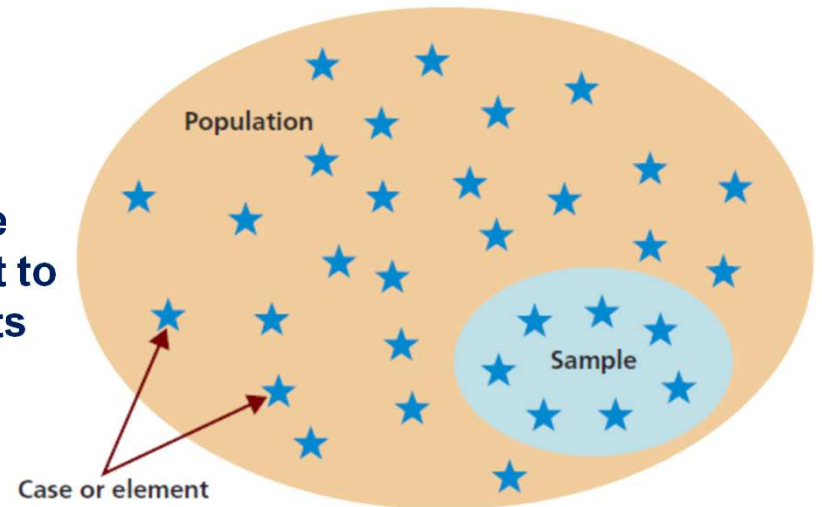
**Random
sampling**



We take a sample from the population and then we want to transfer the obtained results to the entire population.

SAMPLE

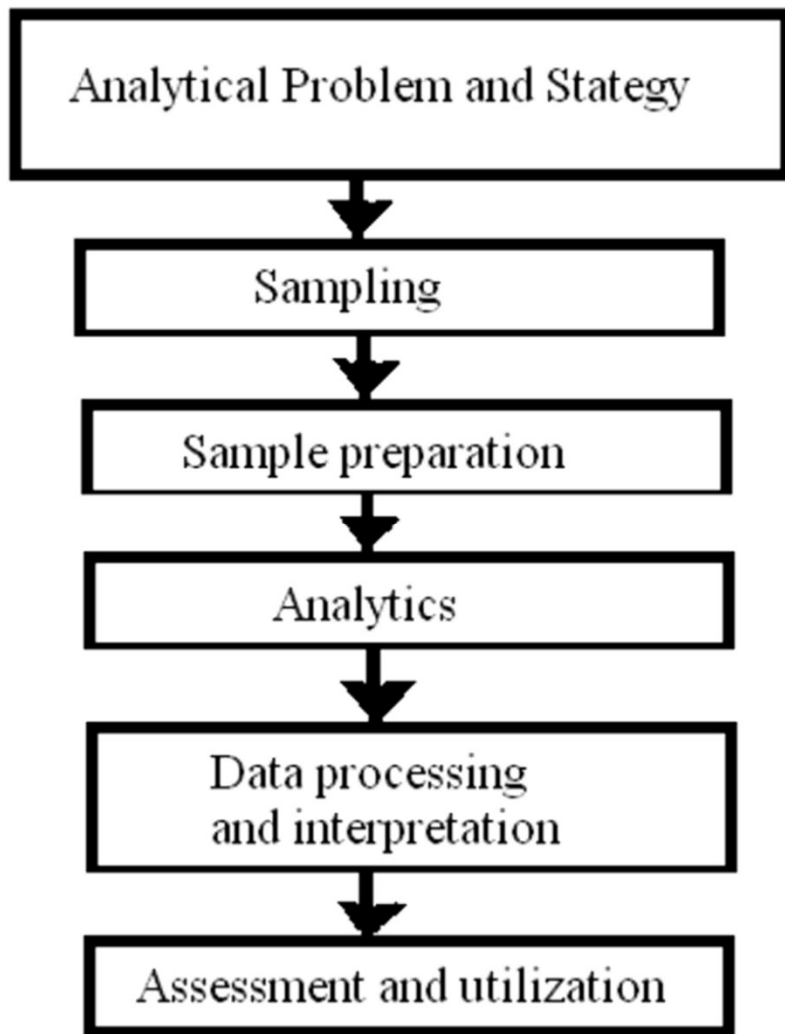
(group that we are able to test)



The sample is required to be **representative** – to describe the structure of the general population. The method of selecting the sample and the size of the sample affect the **representativeness of the sample**.

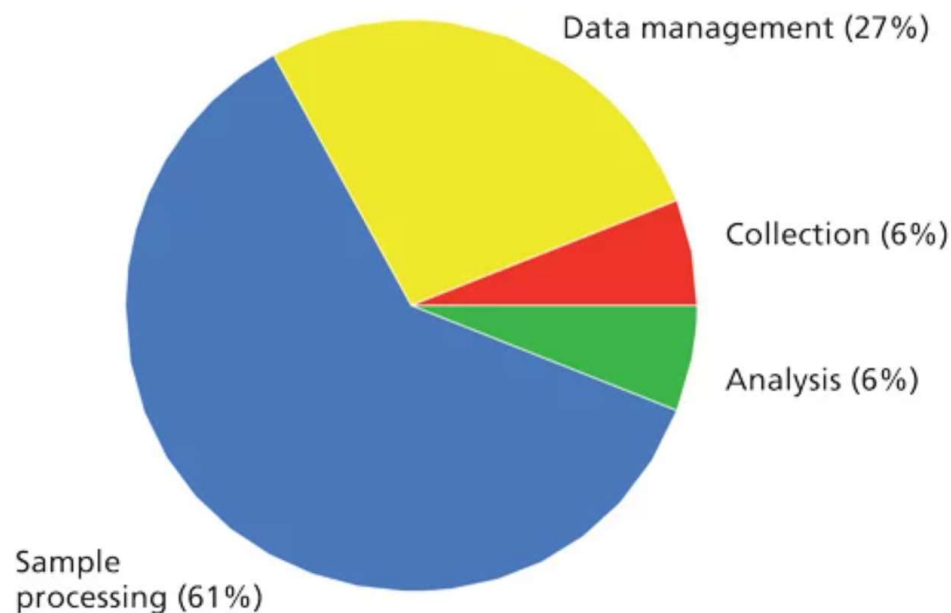
If the sample is randomly selected and is large enough, the sample is said to be representative.

Procedure of analytical method



The "**bottleneck**" of an analytical method is often the sample preparation step, as it is frequently the most time-consuming, complex, and error-prone part of the overall analytical process.

While analytical chemists are developing faster and more efficient techniques, the thoroughness of sample preparation remains critical, acting as a crucial foundation that **can significantly impact the reliability of the final results**.



Statistical analysis of data

Objective of statistical analysis:

- ❑ the need to draw conclusions about a group of measurements being studied
- ❑ inferring characteristics of a group of data by analyzing the characteristics of a small sample of the group

Before statistical analysis of the results, we should ensure a **sufficient number of replications in the study groups** (at least $N=6$) and select an appropriate statistical test.

The number of repetitions should be taken into account when planning experiments.

Results obtained in a single replicate cannot be reported (the result may be unreliable)!!!

Selected statistical test should answer the question of **whether there are statistically significant differences between the compared groups or not.**

Criteria for selecting a statistical test

1

The nature of comparative groups

- Independent
- Dependent

In **independent samples**, subjects in one group do not provide information about subjects in other groups.

Each group contains different subjects and there is no meaningful way to pair them.

Example: A medication trial has a control group and a treatment group that contain different subjects.

In **dependent samples**, subjects in one group do provide information about subjects in other groups.

The groups contain either the same set of subjects or different subjects that the analysts have paired meaningfully.

Example: A training program assessment takes pre-test and post-test scores from the same group of people.

Criteria for selecting a statistical test

2

Number of comparison groups

- 2 groups (test *t*; Student *t*-test)
- more than 2 groups (One-Way Analysis of Variance – ANOVA)

Variance – a measure of the variation among values. It is calculated by adding up squared differences of each value and the mean and then dividing the sum by the number of samples.

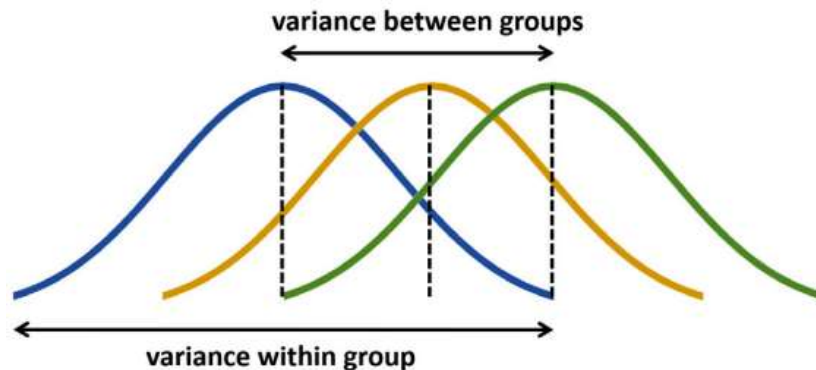
Standard deviation (SD) – the square root ($\sqrt{\quad}$) of variance.

$$Variance = \frac{\sum (x_i - \text{mean})^2}{N}$$

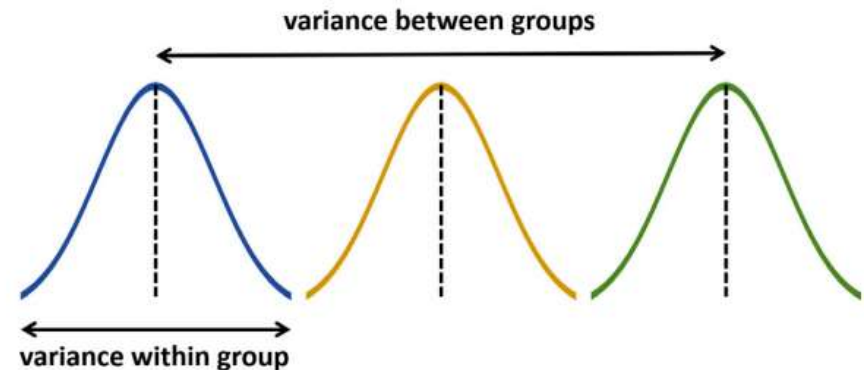
x_i = value *i*

N = number of values

Mean = average of all values



Groups not significantly different

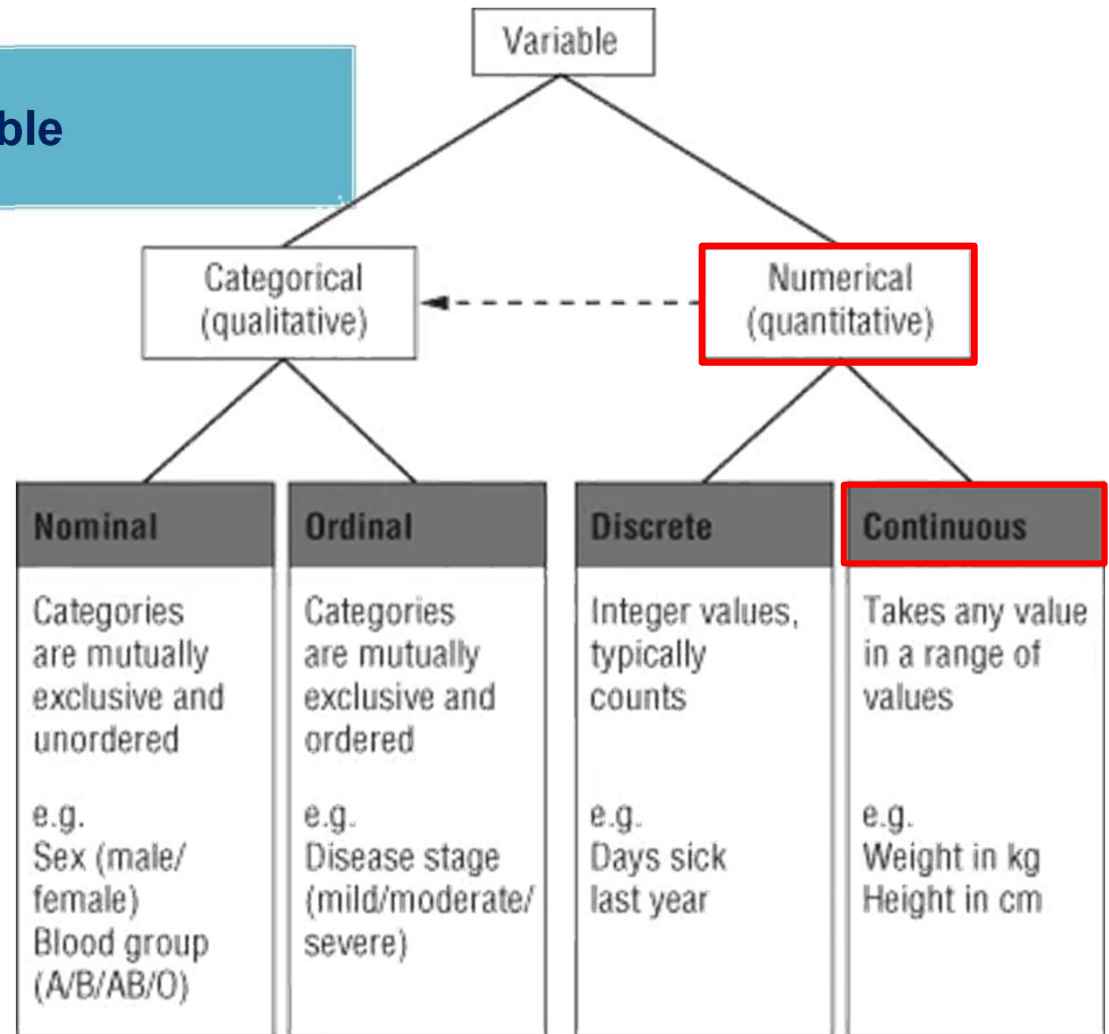


Groups significantly different

Criteria for selecting a statistical test

3

Types of variable

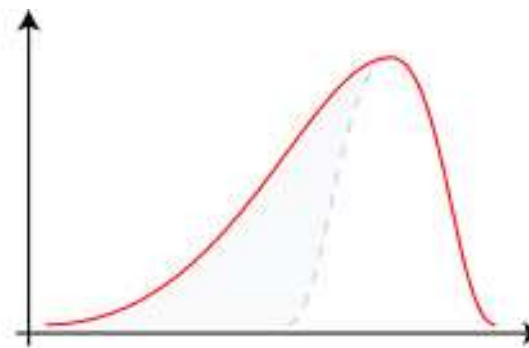
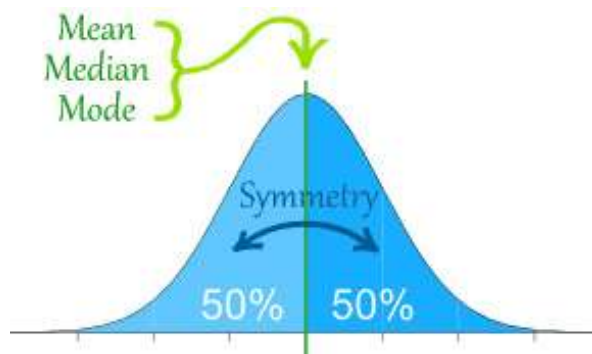


Criteria for selecting a statistical test

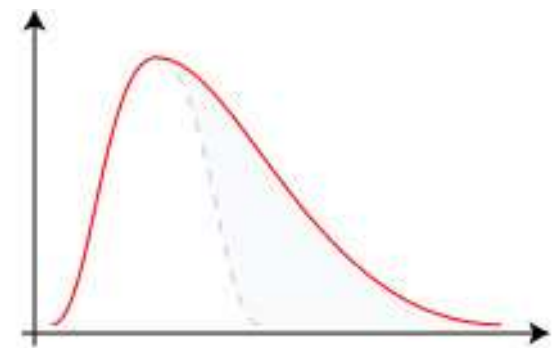
4

The nature of the variable distribution

- normal
- other than normal



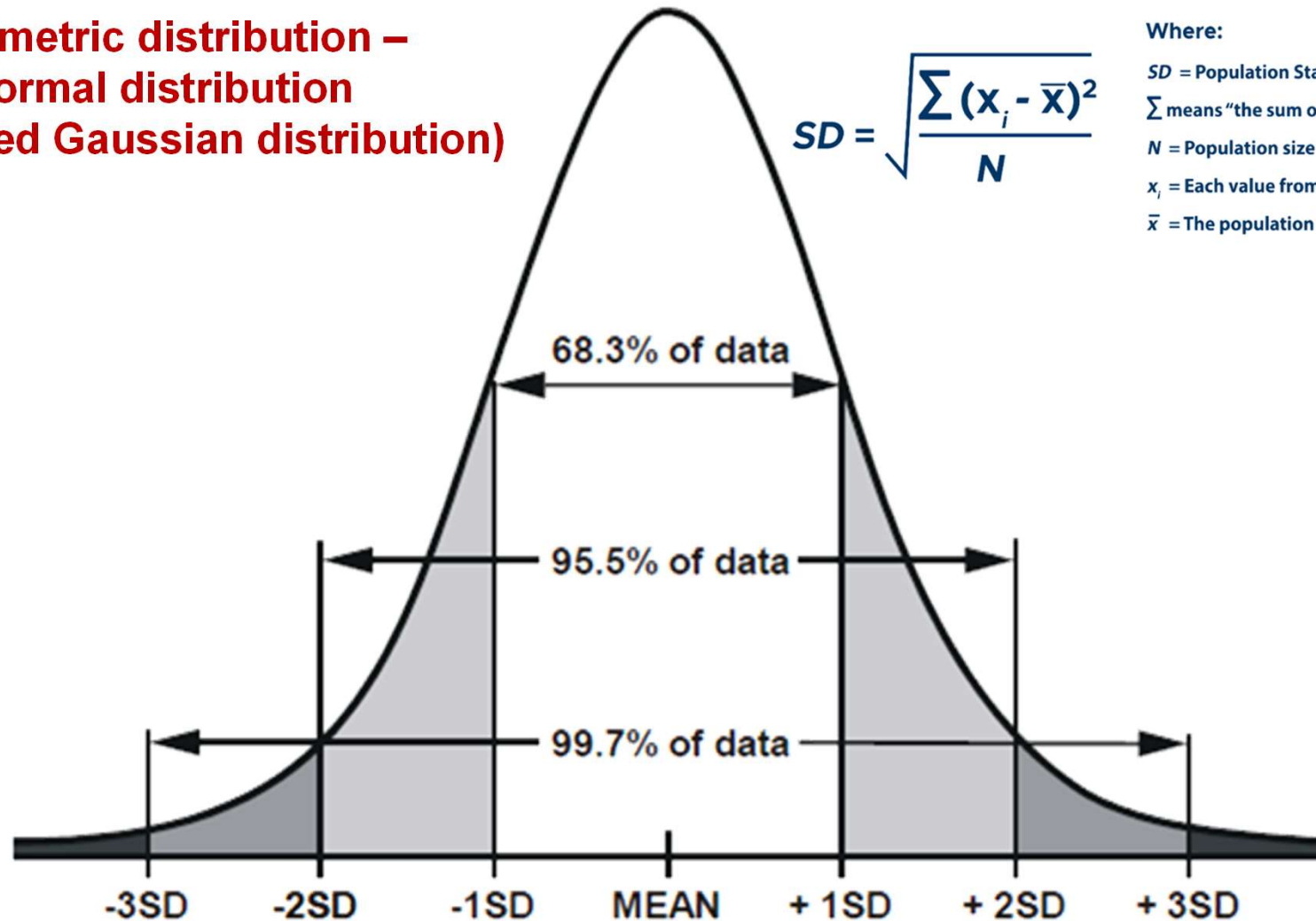
Negative Skew



Positive Skew

Mean and standard deviation

**Symmetric distribution –
Normal distribution
(also called Gaussian distribution)**



$$SD = \sqrt{\frac{\sum (x_i - \bar{x})^2}{N}}$$

Where:

SD = Population Standard Deviation

$\sum$ means "the sum of"

N = Population size

x_i = Each value from the population

$\bar{x}$ = The population Mean

Mean or Median?

[3, 4, 5, 6, 7]



Median

(Odd number of data)

[3, 4, 5, 6, 7, 8]



$(5 + 6) / 2 = 5.5$

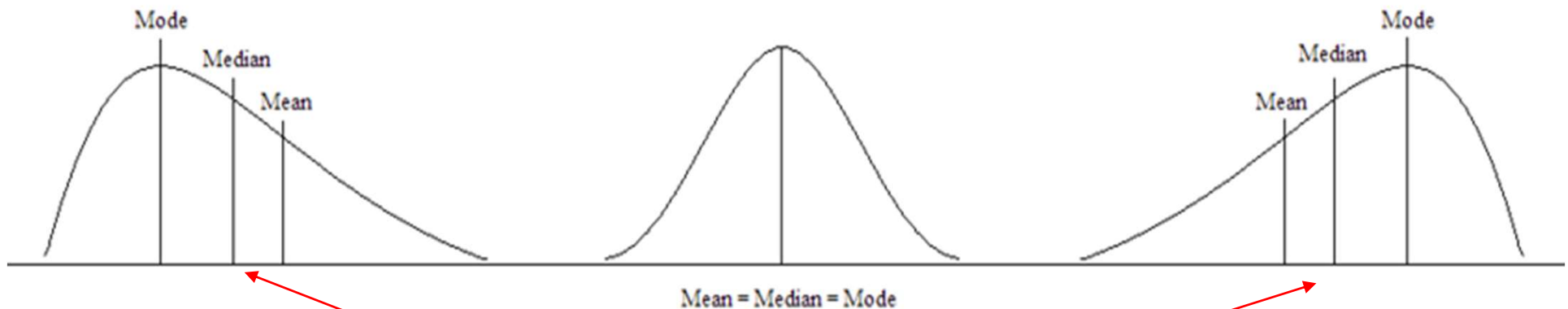
Median

(Even number of data)

Skewed Right

Symmetric Distribution

Skewed Left



The **median** is a better **measure** for an **asymmetric distribution**.

The **mode** is the most frequently occurring value.

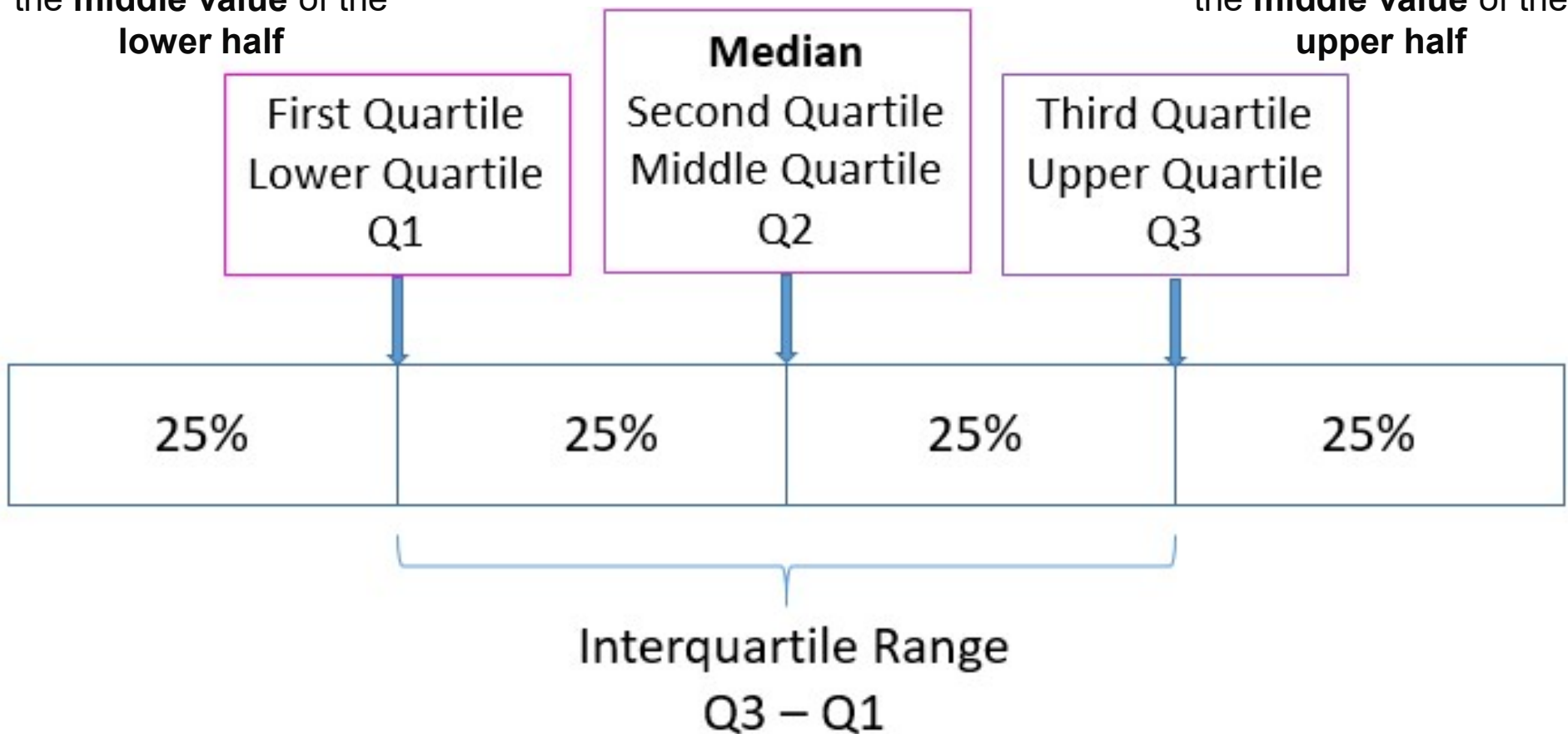
<https://courses.lumenlearning.com/suny-natural-resources-biometrics/chapter/chapter-1-descriptive-statistics-and-the-normal-distribution/>; <https://www.codingem.com/python-calculate-median/>

Median and quartiles

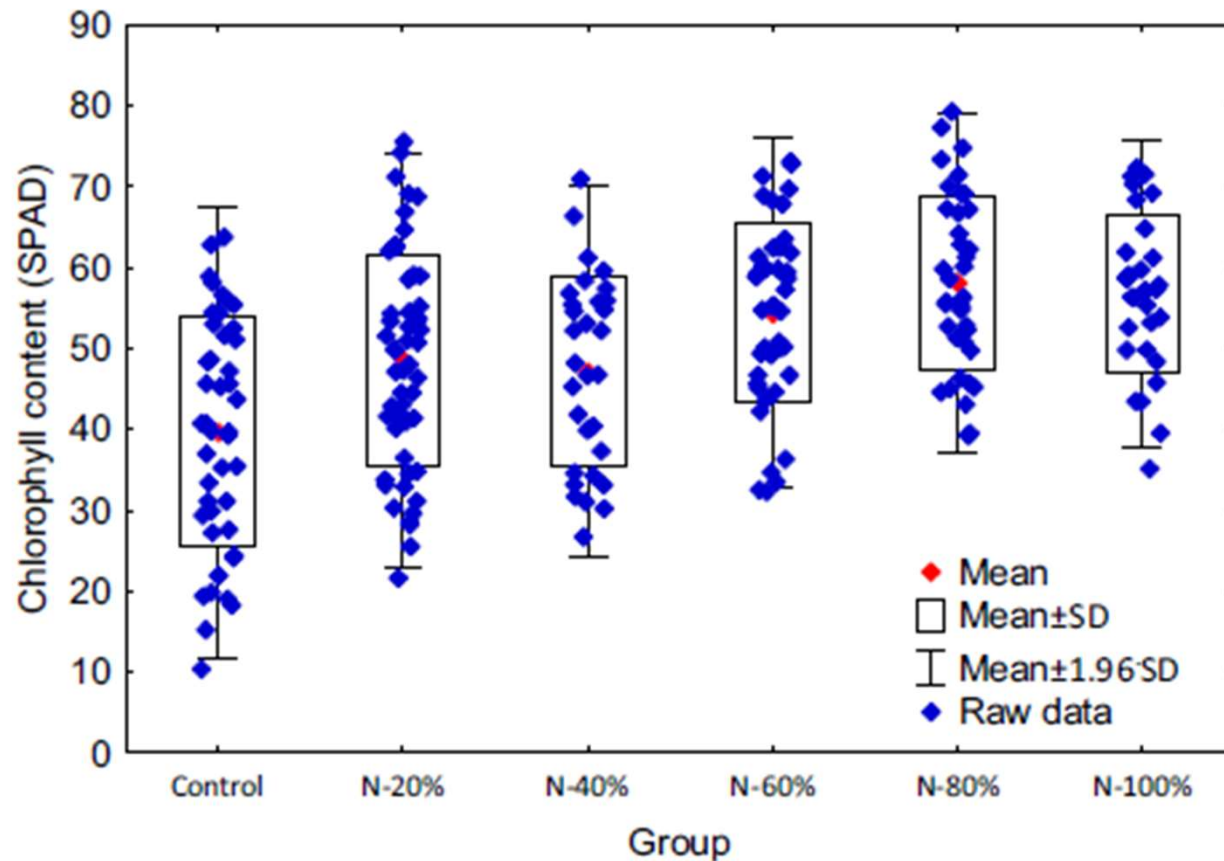
The **lower quartile** is the **middle value** of the **lower half**

The **median** divides the data into a **lower half** and an **upper half**

The **upper quartile** is the **middle value** of the **upper half**



Box & Whisker plot – A normal distribution



Germination tests on
radish

Figure. Effect of different concentrations of algal extract obtained with Neutrase® on the chlorophyll content in radish seedlings

Box & Whisker plot – A non-normal distribution

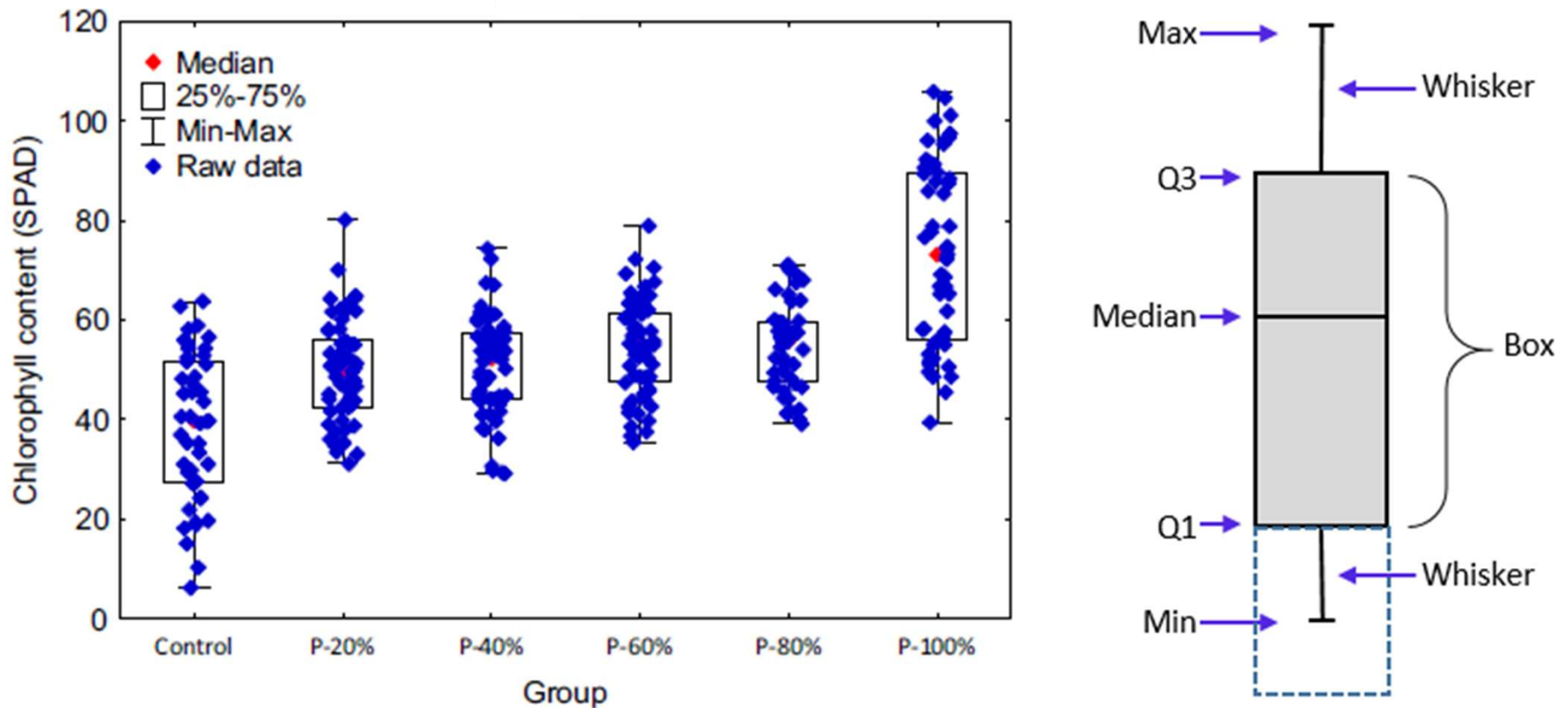


Figure. Effect of different concentrations of algal extract obtained with Protamex® on the chlorophyll content in radish seedlings

Criteria for selecting a statistical test

5

Homogeneity (equality) of variances
in groups

- yes
- no

Homogeneity of variance – is an assumption underlying both *t*-tests and ANOVA tests in which the population variances (i.e., the distribution or “spread” of scores around the mean) of two or more samples are considered equal.

Test selection for independent 2 groups

StatSoft® Polska

Shapiro-Wilk Test
 $p > 0.05$



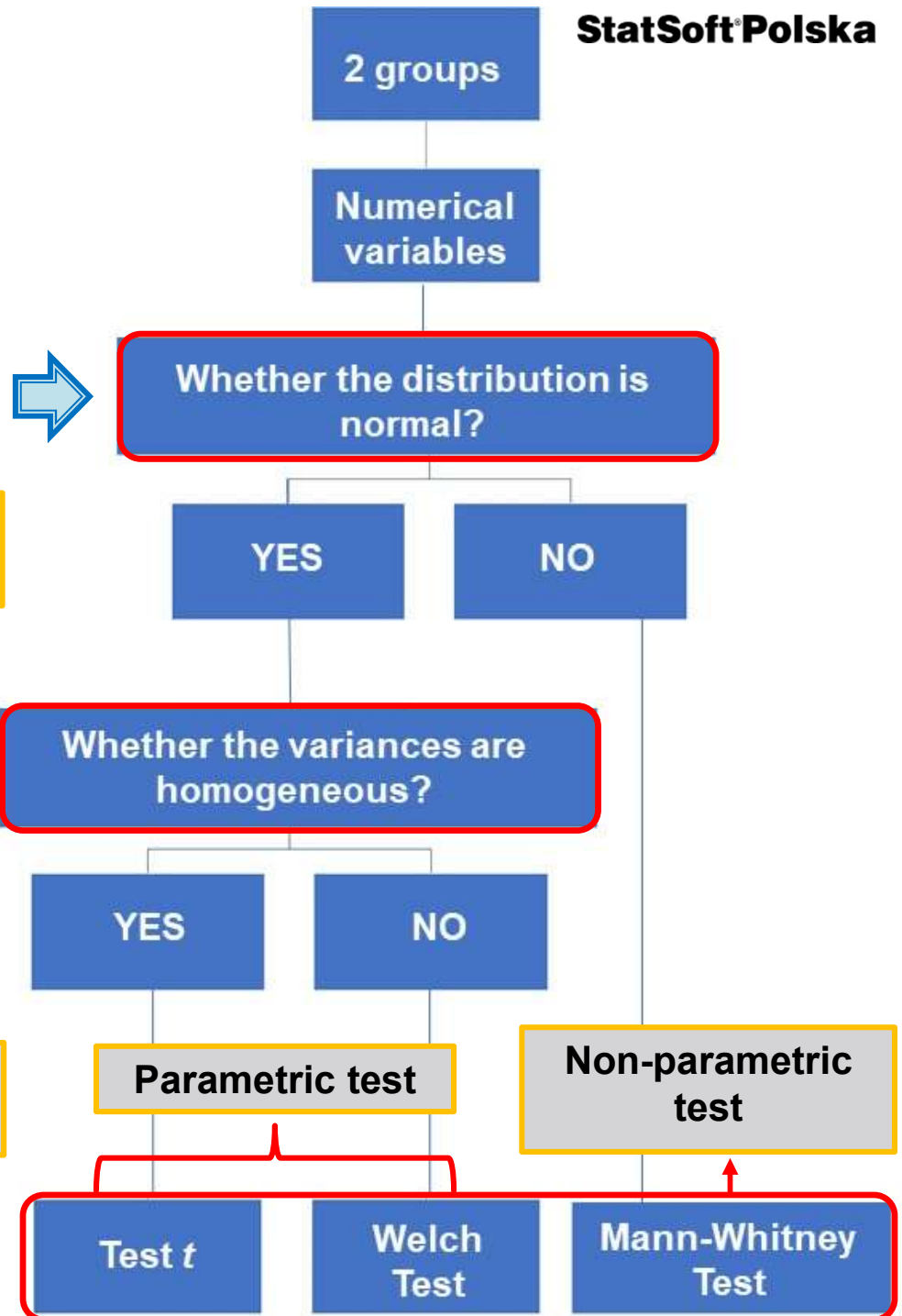
A p value measures the probability of obtaining the observed results

Brown-Forsythe Test
 $p > 0.05$



Statistically significant differences between tested groups

Statistical test
 $p < 0.05$



Test selection for independent more than 2 groups

Shapiro-Wilk Test
 $p > 0.05$

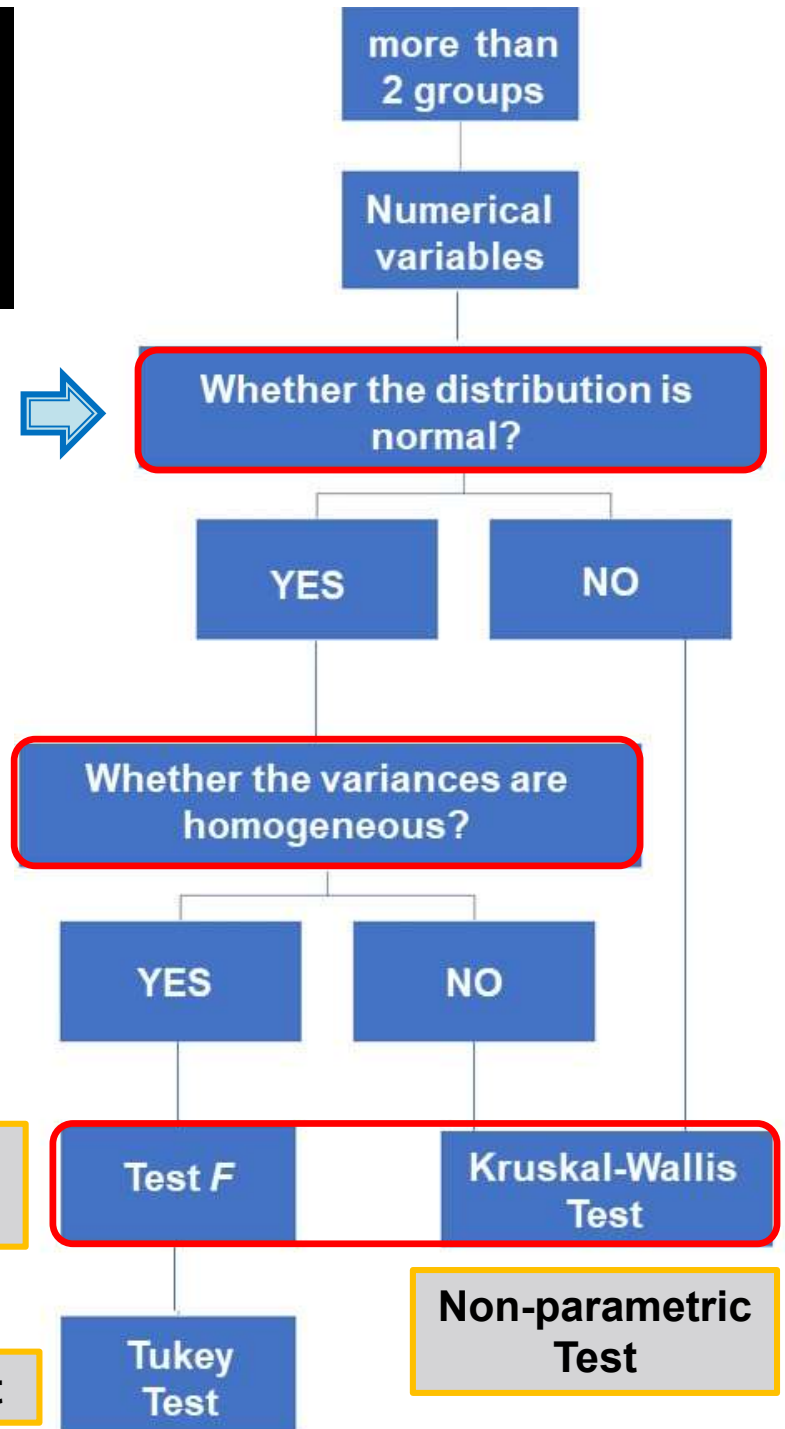
A p value measures the probability of obtaining the observed results

Brown-Forsythe Test
 $p > 0.05$

Statistically significant differences between tested groups

Statistical test
 $p < 0.05$

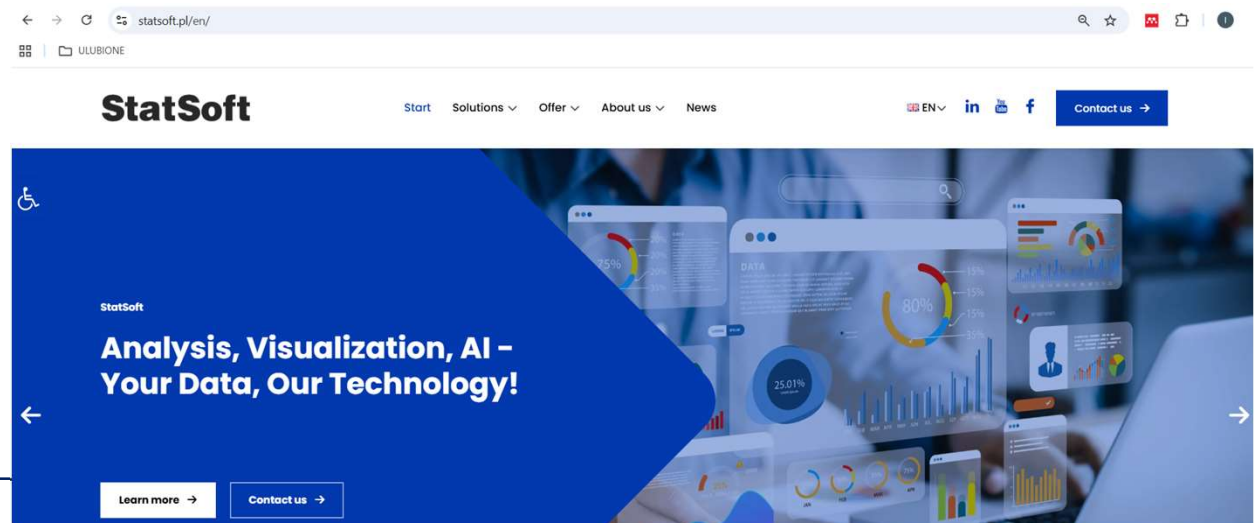
Parametric Test



Example: description of the „Statistical analysis” section in the publication

Most often, this description is in the „**Materials and Methods**” section as the last subsection.

Statistical analysis. Statistical analysis was performed using *Statistica* ver. 13.0 (TIBCO Software Inc., Tulsa, OK, USA). For all experimental groups, descriptive statistics (mean and standard deviations or median and quantiles) were performed. The Shapiro–Wilk test was used to assess the normality of the distribution of experimental results. The Brown-Forsythe’s test was used to check the homogeneity of variances. The statistical test (used to investigate the significance of differences between the tested groups) was selected based on the previously mentioned tests. The one-way analysis of variance (ANOVA) allowed the determination of the statistically significant differences between several groups. The Tukey multiple comparison test was used for normal distribution and homogeneous variances. For the lack of the normal distribution or lack of the homogeneity of variances, the Kruskal–Wallis test was used. The results were considered significantly different when $p < 0.05$.



Interpretation of data / Findings and drawing conclusions

An example of presenting research results from statistical analysis of results – **tests on plants** using different products from macroalgae – seaweed extract or biochar

Germination tests



Pot tests



Interpretation of data / Findings and drawing conclusions

Germination tests on plants using different concentrations of algae extracts vs. control group with distilled water

<https://doi.org/10.1038/s41598-023-36881-z>

Parameter	Root length (cm)	Roots weight (g)	Aboveground part length (cm)	Aboveground part weight (g)	Chlorophyll content— SPAD Index (-)
Group	Median	Mean $\pm$ SD	Median	Mean $\pm$ SD	Mean $\pm$ SD
E (20%)	6.4 ^{a,b} (N = 90)	0.231 $\pm$ 0.077 (N = 4)	3.1 (N = 90)	1.28 $\pm$ 0.20 (N = 4)	55.7 $\pm$ 8.2 (N = 81)
E (40%)	5.3 ^{c,d} (N = 72)	0.180 $\pm$ 0.037 (N = 4)	3.0 ^a (N = 72)	1.03 $\pm$ 0.42 (N = 4)	54.5 $\pm$ 9.6 (N = 65)
E (60%)	5.6 ^e (N = 86)	0.198 $\pm$ 0.035 (N = 4)	3.3 (N = 86)	1.39 $\pm$ 0.22 (N = 4)	55.7 $\pm$ 9.4 (N = 71)
E (80%)	7.1 ^{c,f,g} (N = 78)	0.236 $\pm$ 0.041 (N = 4)	3.6 ^{a,b} (N = 78)	1.42 $\pm$ 0.28 (N = 4)	52.9 $\pm$ 11.3 (N = 63)
E (100%)	4.2 ^{a,f} (N = 71)	0.176 $\pm$ 0.067 (N = 4)	3.0 (N = 71)	1.05 $\pm$ 0.34 (N = 4)	52.5 $\pm$ 12.7 (N = 55)
C (H ₂ O)	3.5 ^{b,d,e,g} (N = 62)	0.175 $\pm$ 0.039 (N = 4)	3.1 ^b (N = 62)	1.24 $\pm$ 0.23 (N = 4)	54.4 $\pm$ 11.9 (N = 57)

Table 2. The results of germination tests on radish seeds treated with various concentrations of seaweed extract. *N* number of measurements in each group, *E* experimental group (extract concentration in the bracket), *C* control group. ^{a,b,c...} Statistically significant differences for $p < 0.05$ (Kruskal–Wallis test; results present as a median).

Example explanation
of the table in the text
of the publication

According to the statistical analysis, various concentrations of *Fucus vesiculosus* extracts influenced radish growth. The median root length in all experimental groups was greater than in the control group, which shows the stimulating effect of *Fucus vesiculosus* extract on the radish root growth. Statistically significant differences were found between E 20% and E 100%, between E 20% and the control group, successively between E 40% and E 80%, and between E 40% and the control group. In addition, statistically significant differences were also found between E 60% and the control group, between E 80% and E 100%, and between E 80% and the control group.

Thank You for Your Attention

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