Table of contents

Volume 441

2020

Previous issue Next issue

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Preface

Papers

Earth and Environmental Science

D M Astutik, L Sulmartiwi, E Saputra and D Y Pujiastuti

+ Open abstract View article PDF

OPEN ACCESS 012004

Maximizing production of a male offspring in *Moina macrocopa* culture through manipulation of rice bran suspension concentration

A S Mubarak, D Jusadi, M Zairin Jr and M A Suprayudi

+ Open abstract View article PDF

OPEN ACCESS 012005

The Concept of the Right to Management of Coastal Communities in the Regional Autonomy Era: Experience from Community Assistance to Obtain the Right to Manage Sea Cucumbers in Sunsak Bay, East Lombok.

A Wahyono and M Illiyani

+ Open abstract View article PDF

OPEN ACCESS 012006

Selective breeding technique: Pandu and Kunti tilapia (*Oreochromis niloticus*) broodstock candidates at PBIAT Janti, Klaten-Central Java

S H Samara, A W Fathurrozi and Sutarno

+ Open abstract View article PDF

OPEN ACCESS 012007

Potential of *Caulerpa racemosa* extracts as sunscreen creams

E B Ersalina, A A Abdillah and L Sulmartiwi

+ Open abstract View article PDF

OPEN ACCESS 012008

Histopathology of the gill of Vaname Shrimp (*Litopenaeus vannamei*) infested by protozoan ectoparasite

S R Pribadi, P D W Sari and S Subekti

+ Open abstract View article PDF

OPEN ACCESS 012009

The effect of iron powder as oxygen absorber active packaging on fish oil total oxidation value

E N Hidayah, RR J Triastuti and A A Abdillah

+ Open abstract View article PDF

OPEN ACCESS 012010

The occurance of endoparasite helminth on Threadfin Bream (*Nemipterus japonicus*) from the fish auction place Mayangan, Probolinggo, East Java

D S Octatriana, P D W Sari and G Mahasri

+ Open abstract View article PDF

OPEN ACCESS 012011

Comparative study of marine fish freshness based on the handling method in Puncak Permai modern market and Simo Gunung traditional market, Surabaya

M Sari, J Triastuti, H Pramono and Sudarno

+ Open abstract View article PDF

OPEN ACCESS 012012

Determination of minimum inhibitory and minimum bactericidal concentration of ketapang (*Terminatia catappa*) leaves extract against *Vibrio harveyi*

A Kharisma, W Tjahjaningsih and Setiawati Sigit

+ Open abstract View article PDF

OPEN ACCESS 012013

The larasati tilapia (*Oreochromis niloticus*) fingerling rearing activity in PBIATJanti, Klaten, Central Java: its performance through survival rate

RV Prasetya, Sutarno and M B Santanumurti

+ Open abstract View article PDF

OPEN ACCESS 012014

Use of hydrogen peroxide to improve potential redox land preparation of land towards increasing production of traditional shrimp vanname (*Litopeaneus vanname*) in Wringin Putih, Muncar, Banyuwangi

D D Nindarwi, L A Sari, P D Wulansari, S H Samara and M B Santanumurti

+ Open abstract View article PDF

OPEN ACCESS 012015

The effect of feed larvae *Chironomus* sp. and high pellet protein to seedling goldfish (*Carassius auratus*)

K H Dwiardani, L A Sari, P. D. W. Sari, D. D. Nindarwi and S. Arsad

+ Open abstract View article PDF

OPEN ACCESS 012016

The maggot flour substitution potency (*Hermetia illucens*) in artificial feed formulation on growth and survival rates of African catfish (*Clarias gariepinus*)

M S Islam, Agustono and M Lamid

+ Open abstract View article PDF

OPEN ACCESS 012017

Influence addition of noni (*Morinda citrifolia*) in the commercial feed on protein and lipid retentions of sangkuriang catfish (*Clarias* sp.).

F Azizah, M Arief and W P Lokapirnasari

+ Open abstract View article PDF

OPEN ACCESS 012018

The growth, protein content, and fatty acid of catfish meat (*pangasius* sp.) With the addition of different lysine doses in commercial feed

E Aristasari, R A Nur 'Aini, W Nopita, Agustono, M Lamid and M A Al-Arif

+ Open abstract View article PDF

OPEN ACCESS 012019

Evaluation of hatching rate, growth performance, and survival rate of cantang grouper (*Epinephelus fuscoguttatus* × *lanceolatus*) in concrete pond at Situbondo, East Java, Indonesia

N S Anita and N N Dewi

+ Open abstract View article PDF

OPEN ACCESS 012020

The effect of temperature, salinity and antimicrobial agent on growth and viability of *Aeromonas hydrophila*

M F Ulkhaq, D S Budi and N N Rahayu

+ Open abstract View article PDF

OPEN ACCESS 012021

Utilization of agar *Gracilaria* sp. as a natural thickener on liquid bath soap formulation

L R Dita, Sudarno and J Triastuti

+ Open abstract View article PDF

OPEN ACCESS 012022

Correlation Between Glucose Level And Protozoan Ectoparasite Infestation Level Of Humpback Grouper (*Cromileptes altivelis*) Nursery In UPBL Situbondo, East Java

G Mahasri, I N D Yodharta, D Novalisa and A T Mukti

+ Open abstract View article PDF

OPEN ACCESS 012023

Study of heavy metal content cadmium (Cd) in various sizes of blood shells (*Anadargranosa*) in coastal Bancaran Bangkalan, Madura

E S Ulfah, B S Rahardja and K T Pursetyo

+ Open abstract View article PDF

OPEN ACCESS 012024

Identification and prevalence of ectoparasites on the fry of Asian sea bass (*Lates calcalifer*), white shrimp (*Litopenaeus vannamei*), and blue swimming crab (*Portunus pelagicus*)

Budianto, H Suprastyani, Q A'yunin and Z Nadlifah

+ Open abstract View article PDF

OPEN ACCESS 012025

Effect of dense stocking of *Gracilaria sp* on growth and survival of milkfish (*Chanos chanos forskal*) on polyculture culture systems

W Isroni, A S Bahri and A A Amin

+ Open abstract View article PDF

OPEN ACCESS 012026

The effect of *Dunaliella salina* extract on NFkB expression in Cantang Grouper (*Epinephelus fuscoguttatus x E. lanceolatus*) exposed by *Viral Nervous Necrosis*

Rani Yuwanita, A Yuniarti, SSP Rahardjo, Q Ayu'nin and AM Madyaratri

+ Open abstract View article PDF

OPEN ACCESS 012027

The Effectiveness of Vaccines in Gurame (*Osphronemus goramy*) and Challenged *Aeromonas hydrophila*

S U Setyaningsih, R Kusdarwati, Rozi and D Handijatno

+ Open abstract View article PDF

OPEN ACCESS 012028

Utilization of By Product *Kappaphycus alvarezii* as Earthquake Resistant Material Lightweight Concrete

A A Musthofa, M Z A Bahtiar, F M Ibrahim and A A Abdillah

+ Open abstract View article PDF

OPEN ACCESS 012029

The effect of density as *Skeletonema costatum* bioremediation agent of copper (Cu) heavy metal concentration

N A Pratama, B S Rahardja and L A Sari

+ Open abstract View article PDF

OPEN ACCESS 012030

Effectiveness of Heat Shock (40°C) With Different Duration for Tetraploid Formed in Mutiara Catfish (*Clarias sp.*) Juvenile

S Nuswantoro, MS Widodo, F Fariedah and E Artarini

+ Open abstract View article PDF

OPEN ACCESS 012031

Histopathological analysis of *Pangasius* sp. infected by *Edwardsiella tarda* causes Edwardsiellosis disease

Q A'yunin, Budianto, S Andayani and R Yuwanita

+ Open abstract View article PDF

OPEN ACCESS 012032

The use of bromelain enzyme on artificial hatching media as an effort to hatch Nile tilapia (*Oreochromis niloticus*) eggs outside the mother's mouth

F Fariedah, M S Widodo, S Nuswantoro and Sholikhin

+ Open abstract View article PDF

OPEN ACCESS 012033

Effects of different feed doses of Majapahit leaves (*Crescentia cujete* L.) on the growth of Nile tilapia (*Oreochromis niloticus*)

S Rahmaningsih, Jumiati and S Awwaliyah

+ Open abstract View article PDF

OPEN ACCESS 012034

Vaname shrimp (*Litopenaeus vannamei*) post-harvest marketing analysis in traditional pond systems at Turi District, Lamongan, East Java, Indonesia

M S A Ningsih, Prayogo and A M Sahidu

+ Open abstract View article PDF

OPEN ACCESS 012035

Effect of probiotic duration and dose of coffee peel fermentation (*Coffea* sp.) on crude protein and crude fiber as an alternative fish feed ingredient

N Fatmawati, Agustono and M Lamid

+ Open abstract View article PDF

OPEN ACCESS 012036

The effect of depuration on lead levels of the cockles *Anadara* sp. by using activated carbon as a filter

A R Firdaus, A S Mubarak and W Tjahjaningsih

+ Open abstract View article PDF

OPEN ACCESS 012037

Growth performance and survival rate of Boeseman's rainbowfish (*Melanotaenia boesemani*) in natural spawning technique at Depok, West Java, Indonesia

W M Akhsan, B Nur and N N Dewi

+ Open abstract View article PDF

OPEN ACCESS 012038

Masculinization of guppies (*Poecilia reticulata*) using water of coconut hybrid variety with the immersion method of pregnant female

G Meiliana, L Sulmartiwi and L Lutfiyah

+ Open abstract View article PDF

OPEN ACCESS 012039

The effect of commercial nutrients to increase the population of *Skeletonema costatum* on laboratory and mass scales

K A Azmi, S Arsad and L A Sari

+ Open abstract View article PDF

OPEN ACCESS 012040

Cultivation technique of *Chanos chanos* modular system and semi intensive at the center for brackish water aquaculture (BBPBAP) Jepara, Central of Java

M Nisa and K Kismiyati

+ Open abstract View article PDF

OPEN ACCESS 012041

Effect of *Spirulina platensis* supplementation in the diet to sperm performance of silver rasbora (*Rasbora argyrotaenia*)

M W D Putri, Prayogo and D S Budi

+ Open abstract View article PDF

OPEN ACCESS 012042

The variances of hematology of gurami (*Osphronemus gouramy*) which is vaccinated and challenged by *Aeromonas hydrophila*

D Alfaniah, R Kusdarwati, Rozi and D Handijatno

+ Open abstract View article PDF

OPEN ACCESS 012043

Antibacterial activity test of mahkota dewa leaf extract (*Phaleri amacrocarpa*) against bacteria *Aeromonas hydrophilla* by in vitro

R A Sarendah, Sudarno and R Kusdarwati

+ Open abstract View article PDF

OPEN ACCESS 012044

The effect of kersen (*Muntingia calabura* L) leaf extract on bacteria *Aeromonas salmonicida smithia* in vitro

N Kartika, Sudarno and D Handijatno

+ Open abstract View article PDF

OPEN ACCESS 012045

Growth and survival rate of silver barb, *Rasbora argyrotaenia* under different concentrations of sardinelle fish oil addition in fish feed

S A Dewi, A S Mubarak and A T Mukti

+ Open abstract View article PDF

OPEN ACCESS 012046

Substitution of fermented soybean juice dregs on catfish (*Pangasius pangasius*) feed formulation toward specific growth rate, efficiency of feed, feed conversion ratio, digestibility of crude protein, and energy

Z N Arifiina, A P Anjarwati, M Lamid and Agustono

+ Open abstract View article PDF

OPEN ACCESS 012047

Addition of lemuru fish oil in feed on the gonadal maturity level of female silver barb, *Rasbora argyrotaenia*

L Agustin, L Sulmartiwi and A S Mubarak

+ Open abstract View article PDF

OPEN ACCESS 012048

The use of mangrove leaves flour *Avicenia rumphiana* as antioxidant feed additive in commercial feed towards growth and survival rate of Nile tilapia fry *Oreochromis niloticus*

D Wulansari, L Sulmartiwi and M A Alamsjah

+ Open abstract View article PDF

OPEN ACCESS 012049

The effect of combination *Bifidobacterium sp* and *Lactobacillus acidophilus* probiotic on egg yolk cholesterol, HDL, and LDL

W P Lokapirnasari, A M Sahidu, L Maslachah, A B Yulianto and R Najwan

+ Open abstract View article PDF

OPEN ACCESS 012050

The effect of using different polar solvents on the stability of thermal extraction phycocyanin from *Spirulina platensis*

D Irawati, A A Abdillah, H Pramono and L Sulmartiwi

+ Open abstract View article PDF

OPEN ACCESS 012051

Substitution of fermented maggot (*Hermetia illucens*) flour on commercial feed towards protein retention and energy retention in tambaqui (*Colossoma macropomum*) meat

N Wantika, Budiana, E Suryani, L Rubi'ah, N Dzatalini, Rusdiatin, Y T Nila, M B Santanumurti, S H Samara, D D Nindarwi *et al*

+ Open abstract View article PDF

OPEN ACCESS 012052

Nile tilapia (*Oreochromis niloticus*) fish hatchery technique: the survival rate evaluation in IBAT Pandaan, Pasuruan, East Java

T A Putri, S Maya and M B Santanumurti

+ Open abstract View article PDF

OPEN ACCESS 012053

Observed snapshot condition of waters during El Niño Southern oscillation (ENSO) 2015-2017 events in the Maluku Channel

A Bayhaqi, D Surinati and H B Prayitno

+ Open abstract View article PDF

OPEN ACCESS 012054

The effect of concrete tanks for the breeding technique of the sand sea cucumber (*Holothuria scabra*)

D A N Sitoresmi and K T Pursetyo

+ Open abstract View article PDF

OPEN ACCESS 012055

Morphometric asymmetry of *Barbodes binotatus* (cyprinidae) collected from three different rivers in Java

S S Astuti, A M Hariati, W E Kusuma and D G R Wiadnya

+ Open abstract View article PDF

OPEN ACCESS 012056

Chlorophyll and carotenoids analysis spectrophotometer using method on microalgae

M Rinawati, L A Sari and K T Pursetyo

+ Open abstract View article PDF

OPEN ACCESS 012057

The effect of catfish and chicken cultivation waste to *Daphnia* sp. culture

N H Holy and L A Sari

+ Open abstract View article PDF

OPEN ACCESS 012058

Neobenedenia girellae infestation on cobia (*Rachycentron canadum*) in Hurun Bay Lampung, Indonesia

R D B Putri, A R Rivaie, S Subekti and P D W Sari

+ Open abstract View article PDF

OPEN ACCESS 012059

Ecotourism development through legality of mangrove processed products dan river tracing in Cemara Beach, Banyuwangi, East Java, Indonesia

E W Setyaningrum, Z Erwanto, K P Prapti, A L Jayanti, A T K Dewi and H D Susanti

+ Open abstract View article PDF

OPEN ACCESS 012060

The effect of various concentration of quail egg yolk on spermatozoa motility of kancra fish (*Tor soro* Valenciennes, 1842) post cryopreservation

M Laeni, Abinawanto, J Subagja and A H Kristanto

+ Open abstract View article PDF

OPEN ACCESS 012061

The fertilization of *Tor soro* fish (Valenciennes, 1842) using post cryopreservation sperm: the effect of skim milk as a cryoprotectant

E R Harjanti, Abinawanto, O Z Arifin and A H Kristanto

+ Open abstract View article PDF

OPEN ACCESS 012062

Honey effect on sperm motility of kancra fish (*Tor soro* Valenciennes, 1842) after 48 hours freezing

B S D Putri, Abinawanto, O Z Arifin and A H Kristanto

+ Open abstract View article PDF

OPEN ACCESS 012063

The spermatozoa viability of kancra fish (*Tor soro*, Valenciennes 1842) 48-hour after freezing: effect of brown sugar as natural cryoprotectant

M A B Pamungkas, Abinawanto, O Z Arifin and A H Kristanto

+ Open abstract View article PDF

OPEN ACCESS 012064

Feed additive of curcuma flour (*Curcuma xanthorhiza*) in commercial feed to growth rate and feed efficiency of tambaqui (*Colossoma macropomum*)

I Oktavianti, Agustono and M Lamid

+ Open abstract View article PDF

OPEN ACCESS 012065

The spermatozoa motility of kancra fish (*Tor soro* Valenciennes, 1842) after the frozen process: the application of egg yolk as a cryoprotectant

N Vardini, Abinawanto, J Subagja and A H Kristanto

+ Open abstract View article PDF

OPEN ACCESS 012066

Sperm motility of kancra fish (*Tor soro*, Valenciennes 1842) after frozen: the effect of soybean milk as a natural cryoprotectant

R Fatriani, Abinawanto, O Z Arifin and A H Kristanto

+ Open abstract View article PDF

OPEN ACCESS 012067

Effect of date palm (*Phoenix dactylifera* l.) on spermatozoa viability of kancra fish (*Tor soro* Valenciennes 1842) 48 hours post cryopreservation

D P Alifiani, Abinawanto, J Subagja and A H Kristanto

+ Open abstract View article PDF

OPEN ACCESS 012068

Effect of *Bacillus* spp. and *Nitrosomonas* sp. in commercial feed as a probiotic agent to increase growth performance and feed efficiency of sangkuriang satfish (*Clarias gariepinus*)

A A Yaqin, Sudarno and Rozi

+ Open abstract View article PDF

OPEN ACCESS 012069

The effect of giving commercial feed, beloso trash fish (*Saurida tumbil*), kurisi trash fish (*Nemipterus nematophorus*), and mixed trash fish on growth of cantang grouper (*Epinephelus fuscoguttatus-lanceolatus*) in floating net cage

M A Nugraha and Rozi

+ Open abstract View article PDF

OPEN ACCESS 012070

The Percentage of embryo viability after 48h sperm cryopreservation: effect of various natural cryoprotectant

S Lestari, Abinawanto, A Bowolaksono, R Gustiano and A H Kristanto

+ Open abstract View article PDF

OPEN ACCESS 012071

Degree of nematode endoparasite infection in asian swamp eel (*Monopterus albus*) from Banyuwangi regency

D I Bakti, G Mahasri, M F Ulkhaq, Kismiyati, D S Budi and Suciyono

+ Open abstract View article PDF

OPEN ACCESS 012072

Effect of different bacterial strain in probiotics on the growth performance of Nile Tilapia (*Oreochromis niloticus*)

T D Sholihuddin, M Arief and H Kenconojati

+ Open abstract View article PDF

OPEN ACCESS 012073

Infection analysis of *Rhadinorhynchus bicircumspinis* in barramundi (*Lates calcarifer*) from pond and floating net cage in Situbondo waters.

D N Putri, S Subekti, M F Ulkhaq, R Kusdarwati, D S Budi and H Kenconojati

+ Open abstract View article PDF

OPEN ACCESS 012074

Population growth and fishery status of the *Lorjuk* shellfish (*Solen* sp.) on Pamekasan beaches, Indonesia

N Trisyani and Kamarudin

+ Open abstract View article PDF

OPEN ACCESS 012075

Prevalence and intensity of protozoan ectoparasite infestation on nursery of humpback grouper (*Cromileptes altivelis*) in hatchery and floating net cage

G Mahasri, S Subekti, B B Angghara and F P Pratama

+ Open abstract View article PDF

OPEN ACCESS 012076

Morphology, morphometrics, and some qualitative parameters of silver rasbora (*Rasbora argyrotaenia*) sperm

L A Adawiyah, L Sulmartiwi and D S Budi

+ Open abstract View article PDF

OPEN ACCESS 012077

Inventory of ectoparasites in pacific white shrimp (*Litopenaeus vannamei*) that cultivated with high density

G D Pamenang, L Sulmartiwi, G Mahasri, N D Rahayu and B Angwarmas

+ Open abstract View article PDF

OPEN ACCESS 012078

Growth of Cantang Hybrid Grouper Juvenile (*Epinephelus fuscoguttatus* x *Epinephelus lanceolatus*) With Different Feeding Frequency

D Nuraini, Agustono and L Lutfiyah

+ Open abstract View article PDF

OPEN ACCESS 012079

The effect of fucoxanthin as coloring agent on the quality of Shrimp Paste

Z Zahrah, M N G Amin and M A Alamsjah

+ Open abstract View article PDF

OPEN ACCESS 012080

The effect of fucoxanthin as coloring agent on the quality of catfish sausage

N W Aditya, M N G Amin and M A Alamsjah

+ Open abstract View article PDF

OPEN ACCESS 012081

The harmful effect of commercial powder detergent on water flea (*Daphnia* sp.)

H Kenconojati, Suciyono and M H Azhar

+ Open abstract View article PDF

OPEN ACCESS 012082

Hematological parameters of Catfish (*Clarias* sp) vaccinated by *Aeromonas hydrophila* with different application methods

V N Nadiro, I Puspitasari, T A Setyastuti and A Santika

+ Open abstract View article PDF

OPEN ACCESS 012083

Detection potential fishing zones of Longtail tuna (*Thunnus tonggol*) using fisheries and remotely sensed data in the waters around Madura Island

A F Syah and M Sholeh

+ Open abstract View article PDF

OPEN ACCESS 012084

Evaluation of aqueous extract of robusta coffee (*Coffea canephora*) leaves for controlling *Argulus japonicus* infestation on common carp seed

N Afifah, Kismiyati and H Kenconojati

+ Open abstract View article PDF

OPEN ACCESS 012085

The different effects of heat shock duration and initial period on hatching rate, abnormality rate, egg yolk absorption, and survival rate of spotted barb (*Puntius binotatus*) larvae

A T Mukti, M Ahmadi, Widjiati and E M Luqman

+ Open abstract View article PDF

OPEN ACCESS 012086

Addition different algae (*Spirulina*) flour to artificial feed on color quality and growth of Koi fish (*Cyprinus carpio-Koi*)

D A Sudirman, M Arief and A H Fasya

+ Open abstract View article PDF

OPEN ACCESS 012087

Tuna fisheries in fisheries management area Republic of Indonesia 572

N Suyasa, P Rahardjo, D R Putri and A Widagdo

+ Open abstract View article PDF

OPEN ACCESS 012088

Optimization of spermatozoa cryopreservation of Albino pangasius catfish: cryoprotectants with various concentrations and different equilibration times

U Hasanah, Abinawanto, A Alimuddin and A Boediono

+ Open abstract View article PDF

OPEN ACCESS 012089

The relation between quality of the sediment (nitrate, phosphate) and *Avicennia sp* density, case study; Mangrove Center Bengkak, Banyuwangi Regency, East Java

Suciyono, B S Rahardja, A I Prayoga, H Kenconojati and M F Ulkhaq

+ Open abstract View article PDF

OPEN ACCESS 012090

The optimal n/p ratio of shrimp culture waste liquid fertilizer on growth of *Chlorella vulgaris*

P A Hidayati, A S Mubarak and Sudarno

+ Open abstract View article PDF

OPEN ACCESS 012091

Profile of Kerandang Fish (*Channa pleurophthalmus* Blkr) Proteins from Central Kalimantan

Aryani, E Suprayitno, B B Sasmito and Hardoko

+ Open abstract View article PDF

OPEN ACCESS 012092

Screening of antivibrio-producing lactic acid bacteria originated from aquatic animals as probiotic candidates

M Amin, M A Liliyanti, N H Nufus and M Ali

+ Open abstract View article PDF

OPEN ACCESS 012093

Length weight relationships and condition factor of sweet river prawn, *Macrobrachium esculentum* (Thalwitss, 1891) in the downstream Rongkong watershed

Jurniati, D Arfiati, A Maizar and A Kurniawan

+ Open abstract View article PDF

OPEN ACCESS 012094

Blood glucose and digestive tract andoparasite helminth infection of cantang grouper (*Epinephelus lanceolatus x Ephelus fuscoguttatus*) from traditional ponds in the Kampung Kerapu of Lamongan East Java

B Angwarmas, L Sulmartiwi, G Mahasri, N D Rahayu and G D Pamenang

+ Open abstract View article PDF

OPEN ACCESS 012095

Inventory of ectoparasite helminth on the Hybrid Grouper (*Epinephelus fuscoguttatus x Epinephelus lanceolatus*) from traditional ponds in the Kampung Kerapu Lamongan East Java Indonesia

N D Rahayu, L Sulmartiwi, G Mahasri, Muntalim, B Angwarmas and G D Pamenang

+ Open abstract View article PDF

OPEN ACCESS 012096

Different Concentration of Rice Bran Suspension on Fecundity and Offspring Production of Each *Moina macrocopa* Broodstock

A Ullimaz, D D Nindarwi and A S Mubarak

+ Open abstract View article PDF

OPEN ACCESS 012097

The spatial pattern of turbidity and light transmission around the coastal waters of Cisadane in July and November 2014

M F Azis Ismail and H B Prayitno

+ Open abstract View article PDF

OPEN ACCESS 012098

Change of hepatopancreas conditions in intensive shrimp aquaculture (*Litopenaeus vannamei*) at Mayangan Village, Legon Kulon District West Java

D A Dana, T A Setyastuti, I Puspitasari and D Sukamto

+ Open abstract View article PDF

OPEN ACCESS 012099

Biology, Ecology and Aquaculture potential of *Osteochilus spilurus* (Bleeker 1851) in East Belitung, Indonesia

A Kurniawan, A M Hariati, A Kurniawan, Kartika, N Rizkika and D G R Wiadnya

+ Open abstract View article PDF

OPEN ACCESS 012100

The effect of seaweed (*Eucheuma cottonii*) age differences as a material on medium density fiberboard (MDF) manufacture

F H Arrosyad and M A Alamsjah

+ Open abstract View article PDF

OPEN ACCESS 012101

Biological activities of Indonesian mangroves obtained by subcritical water extraction

Ratih Pangestuti, Evi Amelia Siahaan, Febriana Untari and Byung Soo Chun

+ Open abstract View article PDF

OPEN ACCESS 012102

Viability of Tor fish spermatozoa (*Tor soro*, Valenciennes 1842) 48-hours cryopreservation: the effects of duck egg yolk as a natural cryoprotectant

P D Wulandari, Abinawanto, J Subagja and A H Kristanto

+ Open abstract View article PDF

OPEN ACCESS 012103

Antiproliferation effects of *Glycine max Linn* ethanolic extract on induced mammary gland carcinoma in albino rats

N M Triana, E Wilujeng, M W H Putri, D M P Yuda, A L Hardiono, M T E Purnama and F Fikri

+ Open abstract View article PDF

OPEN ACCESS 012104

Structure communities of macrozoobenthos in mangrove tourism area, Wongsorejo sub-district, Banyuwangi regency, East Java

D Fatmawati, B S Rahardja, Suciyono, L Lutfiah and M F Ulkhaq

+ Open abstract View article PDF

OPEN ACCESS 012105

Probiotic enriched *Daphnia* sp: the nutritional profile and enzymatic activities

E Riyani, A Yuniarti and A M Hariati

+ Open abstract View article PDF

OPEN ACCESS 012106

Effect of different carbon doses of tapioca (*Manihot esculenta*) flour on vegetative cells and spore production of *Bacillus megaterium*

I M D Mahariawan, N B Ariffin, W E Kusuma, A Yuniarti, M A G Beltran and A M Hariati

+ Open abstract View article PDF

OPEN ACCESS 012107

Enrichment of feed for growth of cantang grouper (*E. fuscoguttatus x E. lanceolatus*) in floating cages

D D Afifah, W H Satyantini, A T Mukti and Y Cahyoko

+ Open abstract View article PDF

OPEN ACCESS 012108

The efficacy of probiotic with different storage to decrease the total organic matter, ammonia, and total *Vibrio* on shrimp pond water

H S Fauziyah, W H Satyantini and D D Nindarwi

+ Open abstract View article PDF

OPEN ACCESS 012109

Analysis degradation of mangrove vegetation in Tangerang District, Banten Province

R Haryanti, A Fahrudin and H A Susanto

+ Open abstract View article PDF

OPEN ACCESS 012110

Determination spesies flying fishes (*exocoetidae*) in makassar strait

Indrayani, A B Sambah, A Kurniawan, A Pariakan, A Jufri and D G R Wiadnya

+ Open abstract View article PDF

OPEN ACCESS 012111

Potential stock of stony corals in Indonesia

T A Hadi, Giyanto, R M Siringoringo, A Budiyanto, O Johan, J Souhoka, M Abrar, N W P Sari, B Sadarun, B Prayudha *et al*

+ Open abstract View article PDF

OPEN ACCESS 012112

Social network analysis: Key actors of cooperation between *Sama* Bajo and land-dwellers in Wakatobi marine national park

T La Ola, N I Wianti, M Tadjuddah, Suriana, T Buana, Rosmawaty, S Abdullah and I A Wunawarsih

+ Open abstract View article PDF

OPEN ACCESS 012113

Niche ornamental-marine fishery of Bangsring and the surrounding areas

D G R Wiadnya, A M Hariati and W E Kusuma

+ Open abstract View article PDF

OPEN ACCESS 012114

The profile of *Carassius auratus* growth and hepatosomatic index in different salinity

L Ningsih, L Sulmartiwi and L Lutfiyah

+ Open abstract View article PDF

OPEN ACCESS 012115

Haematological parameters of Catfish (*Clarias* sp.) fed by immunostimulant added with Cr^{+3} - Yeast (*Saccaromices cerevisiae*) and Garlic

F Indriani, I Puspitasari, T A Setyastuti and A Santika

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Addition of lemuru fish oil in the diet on the fat retention and fatty acid profile of silver barb (*Rasbora argyrotaenia*)

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Addition of Lemuru Fish Oil to Protein Retention and Feed Utilization Efficiency of silver barb *Rasbora argyrotaenia*

R Ayunda, L Sulmartiwi and A S Mubarak

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Study on mangrove canopy cover in Lembeh Island, North Sulawesi

A P Rumengan, C P Paruntu, D Paransa and S H Rumengan

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The immune responses of *Oreochromis niloticus* under different form of *Bacillus* supplementation

A Yuniarti, N B Arifin, N Muawiyah, M Fakhri and A M Hariati

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Response of kutuklin hemaglutinin protein adhesion in koi fish (*Cyprinus carpio*) infected by *Myxobolus* sp.

U Yanuhar, N S Junirahma, N R Caesar, M Musa and G Mahasri

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Effect of different filter media use on aquaponics system on ammonium (NH_4^+), nitrite (NO_2) and nitrate (NO_3) concentrations of catfish (*Clarias* sp.) aquaculture

T A Lukmantoro, Prayogo and B S Rahardja

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Different addition of molasses on feed conversion ratio and water quality in catfish (*Clarias* sp.) rearing with biofloc-aquaponic system

H D Rahmatullah, Prayogo and B S Rahardja

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The different effects of heat shock duration and embryo age on embryonic development and hatching lengths of spotted barb (*Puntius binotatus*) fish

I Rizal, A T Mukti, A S Mubarak, W H Satyantini and Widjiati

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Preliminary study: the effect of cryopreservation on the gastrula-staged embryo of African catfish (*Clarias gariepinus*)

S H Eka, A T Mukti, W H Satyantini and A S Mubarak

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Composition analysis of organic and inorganic waste and the impacts of coastal city in Palu-Central Sulawesi

J Y Walalangi, T D Lelono, A M Suryanto, A Damar, H Effendi and E Susilo

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Growth rate and survivorship of *Acropora* sp. fragments that transplanted on the artificial substrate made from *fly ash* and *bottom ash*

R I Khasanah, E Y Herawati, A M Hariati, M Mahmudi, A Sartimbul, D G R Wiadnya, E Asrial, Yudatomo and E Nabil

+ Open abstract View article PDF

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Marine litter distribution in Ampana Beach Tojo Una-Una Regency Central Sulawesi Province

D Sulistiawati, K Mansyur, A E Putra, M Safir, A M Tahya and Z R Ya'la

+ Open abstract View article PDF

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Comparison of water quality and its influences on phytoplankton abundance based on water characteristics in coastal of Banyuwangi Regency, Jawa Timur, Indonesia

E W Setyaningrum, E D Masithah, M Yuniartik, M P Nugrahani and A T K Dewi

+ Open abstract View article PDF

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The differences of depth on the species composition of spiny lobster puerulus on south Pacitan Regency East Java

W A Saputra, K A Pambudi, A Setyanto and A Tumulyadi

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Different concentration influence of *Moringa oleifera* leaf aqueous extract immersion against *Argulus japonicus* egg damage

F Idris, Kismiyati and G Mahasri

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The effect of using the initial weight of seedlings by the floating method on the percentage of daily growth of seaweed *eucheuma cottonii*.

W Isroni, A S Bahri and A A Amin

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Nursery method of Jatimbulan Tilapia (*Oreochromis niloticus*) in Pasuruan, East Java

I Anggraeni and P D W Sari

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The effect of distance of floating karamba on placement of phytoplankton abundance in coastal waters of Sathean Village, Langgur - Tual Regency

W Isroni, A S Bahri and A A Amin

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Growth performances of Nile Tilapia, *Oreochromis niloticus*, reared in recirculating aquaculture and active suspension systems

M Amin, L Musdalifah and M Ali

+ Open abstract View article PDF

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Utility of almond leaf (*Terminalia cattapa*) for improving growth and color quality of neon tetra fish (*Paracheirodon innesi*)

I Ardi, M Zamroni and E Setiadi

+ Open abstract View article PDF

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Re-description of lobster fishery following ministerial decree of marine affair and fisheries 56/2016: case study in Pacitan, East Java

W Setyawati, A Setyanto and D G R Wiadnya

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Screening of ammonia-degrading bacteria to reduce ammonia content in the manure of laying hens

M Ali, M Zubair, A Rosyidi and M Amin

+ Open abstract View article PDF

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Provision of bacteria from shrimp pond sediment towards N/P ratio, plankton abundance, and total bacteria in the culture media of white shrimp (*Litopenaeus vannamei*)

W H Satyantini, M Salsabila, D D Nindarwi, A M Sahidu and A T Mukti

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Oxidative stress parameters in landrace pigs slaughtered by the stunning method

M T E Purnama, S F Prayoga, N M Triana, W K Dewi, B S Purnomoaji, D K Wardhana and F Fikri

+ Open abstract View article PDF

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Spawning potential ratio (SPR) of Sulphur Goatfish (*Upeneus sulphureus*): biological basis for demersal fishery management in Java Sea

M A Prayitno, H Setiawan, I Jatmiko, M A Rahman and D G R Wiadnya

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Characterization of nano calcium powder from blood cockle (*Anadara* sp.) shell produced by using different hydrochloric acid concentration

G Y Pramudi, L Sulmartiwi, W Tjahjaningsih, E D Mashitah, Patmawati and M N G Amin

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Relationship of long weight between milkfish (*Chanos chanos* forsskal) and sea cucumber (*Holothuria leucospilot*) that are multi-trophic sea farming

J A Surbakti, I A L Dewi, M A Alamsjah and M Lamid

+ Open abstract View article PDF

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The effect of addition of fish bone meal on the concentration of nitrogen (N), phosphorus (P), and potassium (K) in seaweed liquid organic fertilizer of *Gracilaria* sp.

P T Bhaskoro, W Tjahjaningsih and A S Mubarak

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Activity test of anti-stress from extract of *Datura metel* seeds with ethanol solvent towards blood glucose levels and survival rate of *Osphronemus gouramy* seed in closed system

transportation

M M Mashuda, J Triastuti and K T Pursetyo

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Identification and prevalence infection of helminth in the gastrointestinal tract swamp eel (*Synbranchus bengalensis*) which marketed in Surabaya, East Java

S Subekti, M R Kurniawan and S A Sudjarwo

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Potential concentration of heavy metal copper (cu) and microalgae growth *Spirulina plantesis* in culture media

R M S Budi, B S Rahardja and E D Masithah

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Isolation and identification of bacteria in gastrointestinal of eel (*Anguilla bicolor*) that has potential as probiotic

P Lestari, D Suprapto and G Mahasri

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Effect of fucoidan concentration from *Sargassum* sp. on skin lotion antioxidant activities

R C D Putra, M A Alamsjah and L Sulmartiwi

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Correlation between water quality and prevalence on Koi (*Cyprinus carpio*) which infested by *Argulus* in Mungkid Subdistrict and Muntilan Subdistrict, Magelang Regency, Central Java

R D Yunikasari, Kismiyati and G Mahasri

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The effectiveness of activated carbon as adsorbent in the oil purification process fish by-product of the fish canning industry

A Nadia, S Subekti, A Manan and P Wahyudin

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The effect of hydrochloric acid concentration and temperature demineralization on characteristics of chitin from penshell (*Atrina pectinata*)

I L Nugroho, E D Masithah and K T Pursetyo

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Effect of Mengkudu's (*Morinda citrifolia*) distillation with differential fruit ripeness to control *Argulus* on *Carassius auratus auratus*.

I Asiseh, Kismiyati and G Mahasri

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Effect of enzyme papain against natural flavor of raw meat waste laundering surimi

N A Harahap, W H Satyantini and Sudarno

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Effect of eggs immersion in tanin solution against embryonic development of common carp fish (*Cyprinus carpio* L.)

N Fauziah, E D Masithah and L Sulmartiwi

+ Open abstract View article PDF

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The effect of giving fermented rice bran suspension on fecundity and production of *moina macrocopa* offspring per parent

K Y Damayanti, A S Mubarak and L A Sari

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Concentration of fermented tilapia feces suspension by decomposer bacteria as a feed to induce *moina macrocopa* sexual reproduction

A F Zuhro, A S Mubarak and E D Masithah

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Correlation between Osteoprotegerin Serum Levels and Arterial Stiffness Assessed by Cardio-ankle Vascular Index (CAVI) in Hypertensive Patients

A Ariendanie, J N E Putranto and I G N I R Ranuh

+ Open abstract View article PDF

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The Correlation between Work Stress and Hypertension among Industrial Workers: A Cross-sectional Study

A D Rengganis, A B Rakhimullah and H Garna

+ Open abstract View article PDF

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Hypoxic Preconditioning Effect on the Expression of Intracellular Heat Shock Protein (HSP) 27, HSP 70 and HSP 90 on Cultured Adipocyte-Derived Mesenchymal Stem Cells (AMSCs)

A F Ghaznawie, I G R Suryawan, A Andrianto and A Romdiyana

+ Open abstract View article PDF

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Hypoxic Preconditioning Effects of Bone Marrow-derived Culture Mesenchymal Stem Cells on CD31+ Expression, Vascular Endothelial Growth Factors-a (VEGF-A) and Stromal-derived Sactors-1 Alpha (SDF-1α)

A F Muzakkir, I G R Suryawan and T Yusrizal

+ Open abstract View article PDF

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Correlation between Wall Motion Score Index (WMSI) and Anatomical M-mode (AAM) Systolic Thickening with Functional Capacity in Heart Failure among Post-myocardial Infarction Patients

AF Rahimah, BS Pikir and O Imatsu

+ Open abstract View article PDF

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Effects of Garlic Extract (allicin) on Proliferation of Endothelial Progenitor Cells (EPC) in Patients with Stable Coronary Artery Disease

A Y Putri, B S Pikir, Y H Oktaviono and F Alzahra'

+ Open abstract View article PDF

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Antigen Candidates for Atherosclerosis Vaccine Development

D K S C Putri, M J Al-Farabi and I G R Suryawan

+ Open abstract View article PDF

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Immature Platelet Level in Stable Coronary Heart Disease (CHD) Patients with Diabetes Mellitus compared to Stable CHD Patients without Diabetes Mellitus

D R Balti, A Andrianto, B B Dharmadjati and D N Asmarani

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Correlation Between Arterial and Left Ventricle Diastolic Stiffness in Hypertensive Patients

D Sumantha, E R Utami and B S Pikir

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Neglected Cases of Hypertension in Rural Indonesia: A Cross-Sectional Study of Prevalence and Risk Factors on Adult Population

E P B Mulia and S Prajitno

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The Challenges of Managing Deep Vein Thrombosis in the Elderly: A Narrative Review

E P B Mulia and H Firdausi

+ Open abstract View article PDF

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Effect of Black Tea (*camellia sinensis*) on Serum Adiponectin Level in Atherogenic Diet Rats

E R Utami, M Ardiana, B Lestari, E S Wahyuni, E Widjajanto and R Rizkiawan

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Late Eyelid Reconstruction of Necrotizing Fasciitis

F A Muthie and Sutjipto

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Difference in the Level of p-Selectin Blood Edge between Uni-Valvular and Multivalvular in Rheumatic Heart Disease

F Filianovika, A Lefi, R Romdoni and M F Ramadhan

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Importance of Basal Soluble ST2 and Global Longitudinal Strain 2D-Speckle Tracking Echocardiography to Detect Left Ventricle Remodeling in Post-Myocardial Infarction Patients

F S Hasibuan, M Aminuddin, B Utomo and I S Pratama

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Left Atrial Volume Index (LAVI) as an Indicator of Severity and Pulmonary Hypertension in Mitral Stenosis

G M Rahman and A Subagjo

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Contrast does not Affect Adipose Mesenchymal Stem Cell (AMSC) Proliferation

G R Soekarno, I G R Suryawan, A Andrianto and W M Valentidenta

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The Clinical Benefit of D-ribose in Cardiovascular Ischemic Disease: A New Potential Energy Supplement

I Damanik and D Soemantri

+ Open abstract View article PDF

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Association between White Blood Cell to Mean Platelet Volume Ratio (WMR) with Troponin for Refractory Angina Prediction in NSTE-ACS patients

I E Hermawati and M Y Assegaf

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Lower Gensini Score in Navy Personnel Compared to Civilians, rather than for Non-Commissioned Officers

I G P G Semita, M J Al-Farabi, M F Huda, B Jovie and I G R Suryawan

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Correlation between Global Longitudinal Strain (GLS)-Left Ventricle and TEI Index (TI) with Seattle Heart Failure Model (SHFM) Score in Chronic Heart Failure Patients with Systolic Dysfunction

I Kartikasari, A Lefi, D Soemantri and R R Juwita

+ Open abstract View article PDF

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Atria Score for Antithrombotic Agent Utilization in Ischemic Stroke Patients with Atrial Fibrillation

I P Dewi, K P Dewi and R T Pinzon

+ Open abstract View article PDF

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Renal Artery Stenosis: The Challenging in Diagnosis and Therapy

I P Dewi and N Mardiana

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Plasma Histamine Level as a Distinguishing Factor between Stable Coronary Artery Disease and Acute Coronary Syndrome

I S Prihatiningsih, J N E Putranto, D Soemantri and A S Hadi

+ Open abstract View article PDF

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Correlation between Left Ventricular Function with Functional Capacity in Post Infarct Myocard Patients with Heart Failure

I Sudirman, B S Pikir and L G P Rinjani

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Fibrinogen and Low-Density Lipoprotein (LDL) Cholesterol Levels with the Occurrence of Acute Myocardial Infarction: Is it Correlated?

I S Warno, J N E Putranto and B Novitalia

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Supine Percutaneous Nephrolitholapaxy Profile in Jombang General Hospital from 2017 until 2018

J H Purba, F Surahmad and J Renaldo

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The Correlation between p53 Serum Levels and Vascular Age was Measured by Carotid Intima Media Thickness (CIMT) in Patients with Moderate Cardiovascular Risk Factors

J R S Tengor, D Soemantri, J N E Putranto and B F K Putra

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Cluster of differentiation 36 (CD 36), ENac, and AQP 2 effects on heart

J Sunariani

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Systolic Function is Related to the Quality of Life in Chronic Heart Failure Patients

K A Sholafi, R B Wicaksono, R I Gunadi, R Herdyanto and A Andrianto

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Correlation between Serum Galectin-3 Level with Wall Motion Score Index in Patients with ST-Segment Elevation Myocardial Infarction

K Halid, M Aminuddin and I P Dewi

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The Correlation between Serum Tryptase Level and Ventricular Remodeling in Patient with Acute Coronary Syndrome After 1 Month of Onset

L D Yuni, D Soemantri and M I Ilman

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Levofloxacin and Drug-Induced Long QT Syndrome (diLQTS): The Incidence and How to Prevent It

L G Catelya, C T Tjahjono and A Hanafi

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The Effect of Atorvastatin Administration before Percutaneous Coronary Intervention on Stable Coronary Artery Disease Against Event of Periprocedural Myocardial Infarction

L P C Dewi, R M Yogiarto, I G R Suryawan and M D Pratama

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Correlation between Arterial Stiffness with Left Ventricular Mass Index and Diastolic Function in Patients with Stage 3 and 4 of Non-Diabetic Chronic Kidney Disease

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Thrombolytic Therapy in Octogenarian Patient with STEMI at Buleleng General Hospital

M A Pasha and I K Susila

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The Correlation Between Strain and Strain Rate Left Ventricle with Functional Capacity in Post Myocardial Infarction Patients with Heart Failure

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Predicting the Likelihood for Severe CAD and CABG Indication on Elective Patients: Comparison of Novel CHA2DS2-VASc-HSF with CHA2DS2 and CHA2DS2-VASc Score

M J Al-Farabi, I G P G Semita, K A Shonafi, R Ramadhiani, B Jovie and A Andrianto

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Early and Late Initiation Time of Statin Administration Effects on Early and Long-Term Outcome in Acute Coronary Syndrome Patients: A Literature Review

M Q A'yun

+ Open abstract View article PDF

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Predictors of Arteriovenous Fistula Early Failure in End-Stage Renal Disease Patients: Real-World Data in Surabaya

M R Amadis, J N E Putranto, I Maghfirah and N Mardiana

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Different Grades of Body Mass Index are Correlated with Left Atrium and Ventricle Structures in Patients with Hypertensive Heart Disease

M S Bhisma, M J Al-Farabi and B S Pikir

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Comparison of water quality and its influences on phytoplankton abundance based on water characteristics in coastal of Banyuwangi Regency, Jawa Timur, Indonesia

E W Setyaningrum[1], E D Masithah[2], M Yuniartik[1], M P Nugrahani[1], A T K Dewi[1]

[1]Department of Fisheries, Universitas 17 Agustus 1945 Banyuwangi, Jl. Adi Sucipto 26, Banyuwangi, 68416.
[2]Universitas Airlangga Surabaya, Jl. Airlangga No.4 - 6, Airlangga, Kec. Gubeng, Kota Surabaya 60115
[3]Department of Agrotechnology, Universitas 17 Agustus 1945 Banyuwangi, Jl. Adi Sucipto 26, Banyuwangi, 68416.
[4]Department of Industrial Engineering, Universitas 17 Agustus 1945 Banyuwangi, Jl. Adi Sucipto 26, Banyuwangi, 68416

Abstract. Coastal waters of Banyuwangi Regency, East Java, Indonesia obtains water resources from residential areas, the fishing industry, the shipping industry in the surrounding area. This study aims to determine the influences of water quality on phytoplankton abundance, seen from differences characteristics of coastal waters of Banyuwangi. The research method is descriptive. Data collection technique is observation, with the required data including water quality parameters (Sn, PO_4, Total Organic Matter, NO_3, Cu Copper, DO, Water Temperature, Pb, Salinity, Alkalinity, pH, and NH_4) and phytoplankton. The analysis used plankton abundance analysis calculated using the Lachlan modification formula (1982), and multiple regression analysis. The analysis result showed that the type of phytoplankton found was green algae *Chlorella* type and blue-green algae *Oscillatoria* type. The abundance of phytoplankton in the coastal area of Banyuwangi is around 12.5 - 513.75 ind/L, where it is included in the level of eutrophic phytoplankton abundance, which waters in a high fertility. There is an influence between water quality on the abundance of phytoplankton on the coast of Wongsorejo, Banyuwangi and Blimbingsari Districts. Whereas in Lampon (Pesanggaran subdistrict), water quality does not affect the abundance of phytoplankton.

1. Introduction

Coastal water has an important role in the marine aquatic ecosystem. However coastal water is easily influenced from terrestrial input from various sources to the ocean [1]. Fertile waters can certainly support the diversity of available biota resources. Aquatic fertility can be indicated by the abundance of available phytoplankton. Changes of water quality can be seen from the abundance and composition of phytoplankton. The presence of phytoplankton in a waters can provide information about water conditions. Even some studies use the phytoplankton ecological index as an indicator of pollution or trophic levels [2]. This may lead to changes in primary productivity in marine aquatic ecosystem.

Changes in primary productivity have been causally linked to the nutrient status of the aquatic ecosystem for over a century. Phytoplankton production is usually dependent upon supplies of Nitrogen (N) and Phosphate (P) to natural water [3].

Plankton is a living organism that floats in water. This organism has a very limited ability to move, so the distribution of these organisms is influenced by water flow conditions. Plankton can be divided into two namely phytoplankton (plant plankton) and zooplankton (animal plankton). Plankton (phytoplankton and zooplankton) have a very large role in aquatic ecosystems because it is a food source for other aquatic animals. The distribution of phytoplankton is influenced by the availability of light in waters or scattered within the euphotic zone. The ability to form organic substances from inorganic substances in water makes phytoplankton known as primary producers [4].

In the food chain (tropical level), phytoplankton occupies the lowest position as the main food source for aquatic animals. It can be said that waters with high phytoplankton primary productivity will have great biological resource potential [5]. Sharmila and Narayanan [6] explained that phytoplankton contributes 90% of photosynthesis in marine water whose production is mostly coupled to the foremost taxonomic groups including *Diatoms*, *Dinoflagellates*, *Coccolithosphores* and *Silicoflagellates*.

Many coastal and inland water systems have been increasingly polluted due to the influence of domestic and industrial waste discharges, high quantity of agro-materials in agricultural runoffs, proliferation and rapid growth of algal blooms (including harmful algal blooms), sediment discharge from floods and rivers, and increased human settlement and encroachment [7]. Coastal of Banyuwangi Regency is the longest coast in East Java which is 175.8 km, including facing the Indonesian Ocean, some facing the Bali Strait and even the Gulf. In the era of industrialization, the coastal area in Banyuwangi Regency was the top priority for industrial development, agribusiness, agro-industry, housing, transportation, ports, and tourism. Increased use of waters as a means of various kinds of community activities can cause changes to these factors. Then the presence and activity of phytoplankton are related to the surrounding aquatic environment [8].

Based on that, the purpose of this study is to compare water quality and its effect on the abundance of phytoplankton based on the characteristics of the waters off the coast of Banyuwangi Regency.

2. Material and methods

Table 1. Observed Aquatic Environment Parameters and Tools/Measurement Methods.

Parameter	Tools / Methods	Information
Biology		
1. Phytoplankton	Haemocytometer	Laboratory Analysis
Water quality		
1. Dissolved oxygen	DO meter/Winkler	Insitu/Laboratory
2. Salinity	Salinometer	Insitu
3. pH	pH meter	Insitu
4. TSS	Spectrophotometer	Laboratory Analysis
5. Amonia	Spectrophotometer	Laboratory Analysis
6. Nitrat	Spectrophotometer	Laboratory Analysis
7. Phosphate	Spectrophotometer	Laboratory Analysis
8. Temperature	Termometer	Insitu
9. Heavy Metal	Spectrophotometer	Laboratory Analysis

Plankton abundance [12] is calculated using the following formula:

$$N = n \, x \, \frac{Vr}{Vo} \, x \, \frac{1}{Vs}$$

Annotation:

N = Number of individual plankton (ind / L)
n = Number of plankton observed
Vr = filtered plankton volume (ml)
Vo = observed plankton volume (ml)
Vs = volume of filtered water (L)

The next analysis is multiple regression analysis. Regression analysis is performed to determine whether the independent variable, namely water quality, can affect the abundance of phytoplankton (variable bound). The F Statistical Test basically shows whether all independent variables or independent variables entered in the model have an influence together on the dependent variable or the dependent variable. To test this hypothesis F statistics are used with the following decision-making criteria:

- If the regression results on ANOVA significance value is more than the value of confidence 0.05 in other words, we reject the hypothesis, which states that all independent variables simultaneously do not affect the dependent variable.
- It says the hypothesis can be accepted if the significance value is less than the degree of trust sig. 0.05. The hypothesis is accepted, meaning simultaneously all the independent variables affect the dependent variable [12].

The T-test is performed to find out the coefficient of the results of data analysis, and then also can be seen in the multiple linear regression equation. In multiple regression, there is a free variable that is associated with linear Y [13]. If the independent variable x1, x2, ... xk and the independent variable Y, then the general form for multiple regression can be expressed in the equation:

$$Y = a + b_1X_1 + b_2X_2 + ...b_kX_k$$

Annotation :
Y = Dependent Variable (Phytoplankton)
X1, X2, X3, ... = Independent Variable (Water Quality: DO, Temperature, pH, Salinity, NH_4, NO_3, PO_4, CO_3, HCO_3, TOM)
a = Intercept
b1, b2, b3 ... = slope (slope of the line / curve)

The value of determination or R^2 which serves to predict whether or not the influence of independent variables on the dependent variable is needed. A small R2 value means that the ability of the independent variables to explain the variation of the dependent variable is very limited. A value close to 1 means that the independent variables provide almost all the information needed to predict the dependent variation [14].

3. Result and discussion

3.1. Coastal waters of Banyuwangi Regency

The coast of Banyuwangi Regency is located along nine subdistricts, except that in this study the chosen location is six sub-districts which have brackish cultivation activities. And the six districts have different water characteristics. From the northernmost direction, there is the coast of Wongsorejo District, were along the coast there are many intensive brackish cultivation activities. The coastal waters of Wongsorejo Subdistrict are waters that face the Bali Strait directly and are quite influenced by the Java Sea waters, while the bottom waters along the coast are coral and sandy.

To the south, there is the coast of Banyuwangi Subdistrict, which has sandy and muddy waters and directly faces the Bali Strait. In addition, there are also coastal vegetation, namely mangrove, and fir. Likewise, the coastal waters of Blimbingsari Subdistrict are not much different from the waters on the coast of Banyuwangi Subdistrict, both directly dealing with the Bali Strait and the bottom waters are

sandy. It's just that on the coast of the Blimbingsari District there are no mangroves or other coastal vegetation that serves to protect the beach from abrasion, so the waves are higher than on the coast of Banyuwangi.

Next, there are Pangpang Bay waters which are included in the administration of Muncar and Tegaldlimo Subdistricts. In this coastal waters, the characteristic differ from other waters because it is a waters of the bay along the coast there are mangrove vegetation with mud bottom.

Towards the southernmost, there are the coastal waters of Pesanggaran District, in this case entering the Lampon area precisely close to the overlapping gold mine. In this parade directly faced with the south coast precisely the Indian Ocean, so the characteristics are clearly different from other coastal districts.

Based on the explanation above, from the six coastal districts which have brackish cultivation activities, there are three water characteristics, which face directly to the Bali Strait are Wongsorejo, Banyuwangi, and Blimbingsari Districts, which face directly to the bay are Muncar and Tegaldlimo Districts and those that face directly with the Indian Ocean is Pesanggaran District (Lampon).

3.2. Coastal Water Quality in Banyuwangi Regency

Environmental parameter data taken are water quality in the form of temperature, salinity, pH, DO, NH4, NO3, PO4, Alkalinity (CO3, HCO3) and TOM in the coastal waters of Banyuwangi Regency with three replications.

Table 2. Water Quality Data on Coastal Waters of Banyuwangi

Water Quality / Research Site	DO	Water Temperatur	Water pH	Salinity	NH_4 (ppm)	NO_3 (ppm)	PO_4 (ppm)	Alkalinity		TOM
								CO_3 (ppm)	HCO_3 (ppm)	
Coastal District of Wongsorejo	6.90	28.95	7.25	22.67	0.00	0.17	0.03	20.67	120.67	6.90
Coastal District of Banyuwangi	7.12	30.02	7.70	25.50	0.00	0.00	0.02	35.33	102.67	7.12
Coastal District of Blimbingsari	6.25	30.2	8.65	27	0	0	0.1	12	130	6.25
Coastal District of Muncar & Tegaldlimo (Pangpang Bay)	3.97	29.735	6.45	20.5	0.75	0	0	24	107	3.97
Coastal District of Pesanggaran (Lampon)	6.85	30.65	7	25.5	0	0	1.5	44	82	6.85

Based on observations of temperature at the study site in the range 28,95^{0}C - 30,65^{0}C these waters can be classified as waters with normal temperatures for tropical waters. This is, the normal temperature in the tropics ranges from 23^{0}C - 32^{0}C [14].

Dissolved oxygen in these waters is in the range of 3.97 - 7.12 mg / L, so that the waters at the study site are above the minimum dissolved oxygen requirement of 5 mg / L. The content of dissolved oxygen in a waters has a minimum requirement of dissolved oxygen which is a minimum of 5 mg / L [15].

The pH value at the six stations ranges from 6.45 to 8.65, this shows that the pH level in the coastal waters of Banyuwangi Regency is still in the normal range. While the average pH of seawater varies, although not too large, ranging from 7.8 to 8.4 [16], and seawater, in general, has a pH ranging from 7.6 to 8.3 [17].

Salinity in the coastal waters of Banyuwangi District is classified as normal salinity with a range of 25-27 ppt. While salinity in seawater ranges from 24-35 ppt. The distribution of salinity at sea is influenced by various factors such as water circulation, evaporation, rainfall, and river flow [4].

The nitrate content at the sampling point was obtained in the range 0.8 -5 mg / L. The nitrate content in the coastal waters of Banyuwangi District, comes from the river flow in the research location and also comes from the existing shrimp farming ponds. According to the Decree of the Minister of Environment in 2004 this value indicates that the nitrate content is above the quality standard threshold (0.008 mg / L) which means that the nitrate content in the coast of Banyuwangi Tinggi District.

The phosphate contained in this study site is sourced from streams, household waste, and the aquaculture industry. The range of phosphate in the waters is between 0.1-1.75 mg / L, which means that the phosphate content in the coastal waters of Banyuwangi District is above the standard threshold of phosphate (0.015 mg / L). This value according to the Decree of the Minister of Environment in 2004 has also been above the quality standard threshold (0.015 mg / l) which means that the phosphate content at this research site is in an abnormal condition.

3.3 The abundance of phytoplankton on the coast of Banyuwangi Regency

Based on the results of observations made, the type of phytoplankton found was green algae Chlorella type and blue-green algae Oscillatoria type. While the abundance of phytoplankton abundance on the coast of Banyuwangi Regency ranges from 12.5 - 513.75 ind / L. for trophic status of waters, the abundance of phytoplankton in the coastal waters of Banyuwangi Regency is included in the level of Eutrophic phytoplankton abundance, namely waters with high fertility due to phytoplankton abundance of> 15,000 ind / ml [18].

Table 3. Phytoplankton Data in the Coastal Waters of Banyuwangi

Research Site	Phytoplankton (ind/L)
Coastal District of Wongsorejo Wongsorejo	94.286
Coastal District of Banyuwangi	96.25
Coastal District of Blimbingsari	20
Coastal District of Muncar & Tegaldlimo (Pangpang Bay)	12.5
Coastal District of Pesanggaran (Lampon)	513.75

Based on the table above, the abundance of phytoplankton in each coast there is a difference. The Pangpang Bay coast has the lowest abundance of phytoplankton and is classified as moderate or Mesotrophic fertility, while the coast of Pesanggaran District (Lampon) has the highest abundance or Eutrophic.

3.4 Effect of Water Quality on Phytoplankton Abundance

Regression analysis was performed using water quality and phytoplankton data which were divided according to the characteristics of the waters that exist in the coastal areas of Banyuwangi. Based on the results of multiple regression analyses conducted between water quality including Sn, PO4, TOM, NO3, Cu, DO, Water Temperature, Pb, Salinity, Alkalinity, pH, NH4 regressed to plankton abundance, the results did not all affect. This shows the difference in water characteristics along the coast of Banyuwangi is indeed quite different.

The influence of water quality on plankton abundance on the coast of Banyuwangi District is shown by the results of multiple regression analysis stating a significant value between water quality and phytoplankton abundance. Thus it can be seen that the abundance of phytoplankton in waters requires water quality conditions that are in accordance with the life of phytoplankton.

The coast of Banyuwangi Regency which is divided into three water characteristics, namely the coast facing the Bali Strait waters, Pangpang Bay waters, and the Indian Ocean waters, from the results of multiple regression analysis between water quality and abundance of phytoplankton, there is an influence only in coastal waters facing the Bali Strait while those in the Gulf and Ocean there is no influence.

Based on the regression analysis, it can be concluded that there is an influence between water quality on the abundance of phytoplankton on the coast of Wongsorejo, Banyuwangi and Blimbingsari Districts.

Table 4. Model Reliability Test (Test F) Effect of Water Quality on Phytoplankton Abundance in Wongsorejo District, Banyuwangi, Blimbingsari.

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	95896510802,904	12	7991375900,242	3,056	0,018[b]
	Residual	44450155863,763	17	2614715050,810		
	Total	140346666666,667	29			

a. Dependent Variable: Phytoplankton abundance.
b. Predictors: (Constant), Sn, PO_4, TOM, NO_3, Cu, DO, Water Temperature, Pb, Salinity, Alkalinity, pH, NH_4.

Probability value of calculated F (Sig.) In the table above is 0.018 less than the 0.05 significance level so that it can be concluded that the estimated linear regression model is suitable to explain the effect of Sn, PO4, TOM, NO3, Cu, DO, Water Temperature , Pb, Salinity, Alkalinity, pH, and NH4 on the value of phytoplankton abundance.
R-Square value of 0.683 indicates that the proportion of the influence of Sn, PO4, TOM, NO3, Cu, DO, Water Temperature, Pb, Salinity, Alkalinity, pH, and NH4 effects on plankton abundance is 68.3%. That is, the values of Sn, PO4, TOM, NO3, Cu, DO, Water Temperature, Pb, Salinity, Alkalinity, pH, and NH4 have a proportion of influence on plankton abundance values of 68.3% while the remaining 31.7% (100% - 68.3%) influenced by other variables that are not in the linear regression model.

Interpretation of Phytoplankton Abundance Models
= 3,066,802,015 + 108,661,536 DO - 86,605,472 Water Temperature + 229,970,744 pH + 33,989,462 Salinity + 11,012,326,291 NH4 + 17,896,347 NO3 + 442,010,745 PO4 - 9,322,343 Alkalinity - 42,351,992 TOM + 8,328,287,487 Copper (Cu) - 19,748,422,962 Lead (Pb) - 325,178,776 Tin (Sn)
Viewed from the oceanographic aspect, the Bali Strait is one of the important waters in the circulation of water masses in Indonesia. The dynamics of its water mass are influenced by the flow of two main water masses, namely the Java Sea water mass in the north and the Indian Ocean water mass in the south. Mixing the two water masses has a positive impact on the quality of the Bali Strait water mass, among others, affecting the nutrient content (nutrients). The waters of the Bali Strait are highly dynamic waters and are influenced by current systems in the Java Sea and the Indian Ocean. Sea currents in the waters of the Bali Strait are bidirectional currents or ocean currents moving in and out of the strait. Changes in the elevation of water levels at both ends of the strait cause currents to move in two opposite directions [18]. While strait waters are hydraulic type currents because the strait connects two bodies 0of water that are affected by tides that are not interconnected. Based on this, the waters of the Bali Strait have a high enough role in the upwelling process so that they affect the abundance of phytoplankton [19].

Further regression analysis can be concluded that water quality has no effect on plankton abundance in Pangpang Bay which is incorporated in the coast of Muncar and Tegaldlimo Districts.
Probability value The calculated F (Sig.) In the Table above values 0.225 is greater than the 0.05 significance level so that it can be concluded that the linear regression model estimated is not feasible to use to explain the influence of Sn, PO4, TOM, NO3, Copper Cu, DO, Water Temperature, Pb, Salinity, Alkalinity, pH, and NH4 to the value of plankton abundance.
Subsequent regression analysis can also be concluded that water quality does not affect the abundance of phytoplankton in Lampon (Pesanggaran District).

Table 5. Model Reliability Test (Test F) Effect of Water Quality on Phytoplankton Abundance on the Lampon Coast (Pesanggaran District).

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2476465000000,001	5	495293000000,000	1,072	,487[b]
	Residual	1847362500000,000	4	461840625000,000		
	Total	4323827500000,001	9			

a. Dependent Variable: Phytoplankton Abundance
b. Predictors: (Constant), Sn, PO_4, TOM, NO_3, Cu, DO, Water Temperature, Pb, Salinity, Alkalinity, pH, dan NH_4

Probability value of calculated F (Sig.) in the above table is 0.487 greater than the 0.05 significance level so that it can be concluded that the linear regression model estimated is not suitable to be used to explain the effect of Sn, PO_4, TOM, NO_3, Cu, DO, Water Temperature, Pb, Salinity, Alkalinity, pH, and NH_4 on the value of phytoplankton abundance.

Closed waters are waters that are blocked by land or islands in front of it or in the form of bays. So that the strength of the currents and waves will decrease when they arrive at the beach. Closed waters are usually mostly formed from the composition of sand, mud or silt resulting from sedimentation or sedimentation, usually located near river mouths. Mud has more complex substance than sand and has higher organic matter. The mud itself consists of sand, but the more important material is silt and clay whereas, good mud sediment can only be formed on the basis of low wave movement or deeper location so that the waves are not too affected [21].

Based on table 3, for all coastal waters of Banyuwangi Regency, they are included in Eutrophic waters or high phytoplankton abundance, except Pangpang Bay coast which has an abundance in the medium category or is called Mesotrophic, the abundance level is around 2,000 - 15,000 ind / ml, while Pangpang Bay is as much as 12,500 ind / ml.

That is because of all the coastal waters in Banyuwangi Regency, only Pangpang Bay which is a closed waters is different from other waters that enter the open waters so that greater water circulation. This is the cause of the bay waters easily heat faster. Where the light is too strong intensity will damage chlorophyll in a reaction called photo-oxidation [21].

For coastal areas in Pesanggaran subdistrict, the abundance of phytoplankton is indeed quite high compared to other coastal waters in Banyuwangi Regency, because it is dealing directly with the Indian Ocean, where the upwelling process that occurs at this location is also quite high, which is the movement of water mass from the inner layer that rises to the surface . The mass of water from the inner layer has lower temperatures and higher salinity than the surface layer. Because of the magnitude of this upwelling process which then stirs the nutrients in the bottom waters up so that it becomes sufficient intake in the growth of phytoplankton.

However, the quality of water available in the coastal areas of the Ocean does not affect the abundance of phytoplankton, given the strong currents from the Indian Ocean that cause high waves compared to other coasts in Banyuwangi.

4. Conclusion

Based on the results of the analysis it was concluded that the type of phytoplankton found was green algae *Chlorella* type and blue-green algae *Oscillatoria* type. While the abundance of phytoplankton abundance in the coastal area of Banyuwangi is around 12.5 - 513.75 ind / L, where the abundance of phytoplankton is included in the level of eutrophic phytoplankton abundance, namely waters with high fertility. Based on the subsequent analysis of regression analysis, there is an influence between water quality on the abundance of phytoplankton on the coast of Wongsorejo, Banyuwangi and Blimbingsari Districts. Whereas in Lampon (Pesanggaran subdistrict) it can be concluded that water quality does not affect the abundance of phytoplankton.

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