**Appendix 1**. Spatio-temporal distribution of benthic macro invertebrates in Kulathupuzha during study period 2021-2023.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Order** | **Genus/species** | **S1** | **S2** | **S3** | **S4** | **S5** | **S6** |
| Architaenioglossa | Viviparus viviparus | 0 | 0 | 1 | 0 | 0 | 1 |
| Coleoptera | Rhantus spp. | 0 | 1 | 0 | 0 | 0 | 0 |
|  | Dytiscus spp. | 1 | 0 | 0 | 0 | 0 | 1 |
|  | Hyphydrus spp. | 0 | 0 | 1 | 1 | 1 | 0 |
|  | Neptosternus spp. | 0 | 0 | 0 | 0 | 1 | 1 |
|  | Elmid spp. | 0 | 1 | 1 | 1 | 1 | 1 |
|  | Stenelmis spp. | 1 | 0 | 0 | 0 | 1 | 1 |
|  | Gyrinus spp. | 1 | 2 | 0 | 1 | 0 | 0 |
|  | Hydrophilus spp. | 2 | 1 | 1 | 0 | 2 | 0 |
|  | Laccobius sp | 1 | 0 | 1 | 2 | 2 | 1 |
|  | Hydrocanthus spp. | 0 | 0 | 0 | 0 | 1 | 1 |
|  | Noterus spp. | 0 | 0 | 0 | 0 | 1 | 0 |
|  | Psephenus spp. | 1 | 1 | 0 | 0 | 2 | 1 |
|  | Scirtes spp. | 0 | 0 | 1 | 1 | 2 | 1 |
|  | Hydrocyphon spp. | 1 | 0 | 0 | 1 | 1 | 2 |
|  | Cyphon spp. | 2 | 1 | 0 | 2 | 2 | 2 |
| Decapoda | Caridina spp. | 0 | 1 | 1 | 0 | 1 | 1 |
|  | Atyid spp. | 0 | 1 | 0 | 0 | 0 | 1 |
|  | Caridina shenoyi | 0 | 0 | 0 | 0 | 1 | 1 |
|  | Travancoriana spp | 1 | 0 | 0 | 0 | 0 | 2 |
|  | Parathelphusa spp. | 0 | 2 | 2 | 0 | 0 | 2 |
|  | Macrophthalmus spp. | 1 | 0 | 0 | 0 | 0 | 0 |
|  | Macrobrachium spp. | 0 | 1 | 0 | 0 | 1 | 0 |
|  | Varuna litterata | 0 | 1 | 0 | 0 | 0 | 1 |
|  | Penaeus spp. | 0 | 1 | 0 | 0 | 0 | 1 |
|  | Atherix spp. | 1 | 1 | 1 | 0 | 0 | 1 |
|  | Atrichops spp. | 0 | 1 | 0 | 0 | 0 | 0 |
|  | Dasyhelea spp. | 1 | 0 | 1 | 2 | 0 | 0 |
|  | Bezzia spp. | 0 | 0 | 1 | 1 | 0 | 0 |
|  | Ablabesmyia spp. | 2 | 1 | 0 | 0 | 2 | 0 |
|  | Chironomus spp. | 1 | 0 | 0 | 2 | 2 | 3 |
|  | Culiseta spp. | 0 | 1 | 0 | 0 | 1 | 0 |
|  | Culex spp. | 0 | 1 | 0 | 0 | 2 | 0 |
|  | Anopheles spp. | 0 | 0 | 0 | 1 | 0 | 0 |
|  | Rhamphomyia spp. | 0 | 0 | 0 | 1 | 0 | 0 |
|  | Limoniid spp. | 2 | 1 | 0 | 1 | 0 | 1 |
|  | Dicranota spp. | 0 | 1 | 1 | 2 | 2 | 1 |
|  | Sepedon. Spp | 0 | 0 | 0 | 1 | 0 | 0 |
|  | Eristalinus spp. | 0 | 1 | 0 | 1 | 0 | 1 |
|  |  |  |  |  |  |  |  |

**(Continued)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Order** | **Genus/species** | | **S1** | | **S2** | | **S3** | | **S4** | | **S5** | | **S6** | |
|  | Simulium spp. | | 0 | | 1 | | 0 | | 0 | | 0 | | 1 | |
|  | Tabanus spp. | | 1 | | 0 | | 0 | | 1 | | 0 | | 1 | |
|  | Tipula spp. | | 0 | | 0 | | 1 | | 2 | | 0 | | 0 | |
|  | Thaumalea spp. | | 0 | | 0 | | 0 | | 0 | | 1 | | 0 | |
| Ephemeroptera | Ameletus spp. | | 0 | | 1 | | 0 | | 0 | | 0 | | 0 | |
|  | Baetis spp. | | 1 | | 2 | | 2 | | 1 | | 1 | | 2 | |
|  | Labiobaetis spp. | | 1 | | 2 | | 0 | | 1 | | 1 | | 0 | |
|  | Cloeon spp. | | 1 | | 0 | | 0 | | 1 | | 0 | | 1 | |
|  | Caenis spp. | | 2 | | 3 | | 3 | | 3 | | 2 | | 2 | |
|  | Ephemera spp. | | 1 | | 2 | | 3 | | 1 | | 3 | | 2 | |
|  | Isonychia spp. | | 0 | | 0 | | 0 | | 0 | | 0 | | 1 | |
|  | Afronurus spp. | | 0 | | 1 | | 0 | | 0 | | 0 | | 0 | |
|  | Rhithrogena spp. | | 0 | | 1 | | 0 | | 0 | | 0 | | 0 | |
|  | Choroterpes spp. | | 0 | | 0 | | 0 | | 0 | | 0 | | 1 | |
|  | Choroterpes nambiensis | | 0 | | 1 | | 0 | | 0 | | 0 | | 0 | |
|  | Indialis spp. | | 0 | | 1 | | 0 | | 2 | | 0 | | 0 | |
|  | Habrophlebia spp. | | 0 | | 1 | | 0 | | 0 | | 0 | | 0 | |
|  | Notophlebia spp. | | 0 | | 1 | | 1 | | 0 | | 0 | | 1 | |
|  | Thraulus spp. | | 0 | | 0 | | 1 | | 1 | | 0 | | 0 | |
|  | Thraulodes spp. | | 1 | | 0 | | 0 | | 0 | | 0 | | 0 | |
|  | Isca spp. | | 0 | | 2 | | 0 | | 1 | | 0 | | 0 | |
| Haplotaxida | Nais spp. | | 1 | | 0 | | 0 | | 0 | | 0 | | 1 | |
|  | Tubifex tubifex | | 1 | | 0 | | 0 | | 0 | | 1 | | 1 | |
| Hemiptera | Sigara spp. | | 0 | | 0 | | 1 | | 2 | | 0 | | 1 | |
|  | Naucoris spp. | | 1 | | 2 | | 0 | | 0 | | 0 | | 1 | |
|  | Pelocoris spp. | | 1 | | 1 | | 0 | | 0 | | 0 | | 0 | |
|  | Velia spp. | | 0 | | 1 | | 0 | | 0 | | 1 | | 1 | |
|  | Enithares spp | | 0 | | 0 | | 0 | | 1 | | 0 | | 0 | |
| Lepidoptera | Acronicta spp. | | 0 | | 0 | | 0 | | 0 | | 0 | | 1 | |
| Littorinimorpha | Bithynia tentaculata | | 0 | | 1 | | 0 | | 0 | | 0 | | 1 | |
| Lumbriculidae | Lumbriculis spp. | | 2 | | 0 | | 1 | |  | | 0 | | 2 | |
| Odonata | Vestalis gracilis | | 0 | | 2 | | 1 | | 0 | | 1 | | 0 | |
|  | Heliocypha spp. | | 0 | | 1 | | 0 | | 0 | | 0 | | 1 | |
|  | Argia spp. | | 2 | | 3 | | 2 | | 3 | | 1 | | 2 | |
|  | Ischnura spp. | | 0 | | 0 | | 1 | | 0 | | 0 | | 1 | |
|  | Agriocnemis spp. | | 0 | | 1 | | 1 | | 1 | | 0 | | 1 | |
|  | Cordulegaster spp. | | 1 | | 2 | | 0 | | 3 | | 1 | | 0 | |
|  | Hemicordulia spp. | | 1 | | 0 | | 0 | | 0 | | 0 | | 0 | |
|  | Heliogomphus spp | | 0 | | 0 | | 0 | | 1 | | 1 | | 0 | |
|  | Macrogomphus spp. | | 1 | | 1 | | 0 | | 0 | | 0 | | 0 | |
|  | Megalogomphus spp. | | 0 | | 0 | | 1 | | 0 | | 0 | | 0 | |
|  | **(Continued)** | |  | |  | |  | |  | |  | |  | |
| **Order** | **Genus/species** | **S1** | | **S2** | | **S3** | | **S4** | | **S5** | | **S6** | |
|  | Onychogomphus spp. | 1 | | 0 | | 0 | | 0 | | 0 | | 0 | |
|  | Hagenius spp. | 1 | | 2 | | 1 | | 1 | | 0 | | 0 | |
|  | Gomphus spp. | 0 | | 1 | | 1 | | 0 | | 1 | | 1 | |
|  | Arigomphus spp. | 1 | | 1 | | 1 | | 1 | | 0 | | 0 | |
|  | Paragomphus spp. | 0 | | 1 | | 0 | | 2 | | 0 | | 0 | |
|  | Diplacodes spp. | 0 | | 1 | | 0 | | 0 | | 0 | | 1 | |
|  | Macrothemis spp. | 1 | | 0 | | 0 | | 0 | | 0 | | 0 | |
|  | Libellula spp. | 2 | | 1 | | 2 | | 2 | | 3 | | 1 | |
|  | Sympetrum spp. | 1 | | 0 | | 0 | | 1 | | 0 | | 0 | |
|  | Macromia spp. | 1 | | 2 | | 0 | | 1 | | 1 | | 2 | |
|  | Copera spp | 0 | | 2 | | 0 | | 1 | | 0 | | 1 | |
| Plecoptera | Neoperla   spp | 0 | | 0 | | 0 | | 0 | | 1 | | 0 | |
|  | Perlesta spp. | 0 | | 0 | | 0 | | 1 | | 0 | | 0 | |
|  | Tallaperla spp. | 0 | | 1 | | 0 | | 1 | | 0 | | 1 | |
| Trichoptera | Anisocentropus spp. | 1 | | 1 | | 0 | | 3 | | 0 | | 2 | |
|  | Helicopsyche spp. | 1 | | 0 | | 0 | | 0 | | 0 | | 1 | |
|  | Macrostemum spp | 0 | | 0 | | 0 | | 1 | | 0 | | 0 | |
|  | Hydropsyche spp. | 1 | | 2 | | 0 | | 2 | | 0 | | 1 | |
|  | Limnephilus spp. | 1 | | 2 | | 0 | | 1 | | 0 | | 0 | |
|  | Polycentropus spp. | 0 | | 1 | | 0 | | 0 | | 0 | | 0 | |
|  | Rhyacophila spp. | 0 | | 0 | | 0 | | 0 | | 0 | | 1 | |
| Tubificida | Branchiura sowerbyi | 0 | | 1 | | 0 | | 0 | | 1 | | 0 | |

**Legend:**  S1- Mottal Mood, S2- Marappalam, S3- Perum Padappy, S4- Plavu Chal, S5- Pullu Mala, S6- Poovanathu Mood

**Appendix 2**. Spatio-temporal distribution of benthic macro invertebrates in Shendurney during study period 2021-2023.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Order** | | **Genus/species** | | **S1** | | **S2** | | **S3** | | **S4** | | **S5** | |
| Architaenioglossa | | Viviparus viviparus | | 1 | | 1 | | 0 | | 0 | | 2 | |
|  | | Viviparus georgianus | | 0 | | 1 | | 0 | | 2 | | 0 | |
| Coleoptera | | Rhantus spp. | | 0 | | 0 | | 1 | | 0 | | 0 | |
|  | | Laccophilus spp. | | 1 | | 1 | | 3 | | 0 | | 0 | |
|  | | Dytiscus spp. | | 1 | | 1 | | 2 | | 1 | | 0 | |
|  | | Stenelmis spp. | | 1 | | 1 | | 0 | | 0 | | 1 | |
|  | | Elmid spp. | | 0 | | 1 | | 0 | | 2 | | 0 | |
|  | | Dineutus spp. | | 1 | | 1 | | 0 | | 0 | | 0 | |
|  | | Hydrophilus spp. | | 2 | | 2 | | 3 | | 0 | | 2 | |
|  | | Tropisternus spp. | | 0 | | 0 | | 1 | | 0 | | 0 | |
|  | | Helochares spp. | | 1 | | 0 | | 0 | | 1 | | 0 | |
|  | | Hydrocanthus spp. | | 0 | | 1 | | 1 | | 0 | | 0 | |
|  | | Psephenus spp. | | 1 | | 1 | | 0 | | 0 | | 0 | |
|  | | Cyphon spp. | | 0 | | 1 | | 3 | | 1 | | 2 | |
|  | | Scirtes spp. | | 2 | | 0 | | 2 | | 1 | | 3 | |
|  | | Hydrocyphon spp. | | 2 | | 0 | | 1 | | 0 | | 1 | |
| Decapoda | | Caridina spp. | | 0 | | 2 | | 1 | | 1 | | 0 | |
|  | | Caridina gracilirostris | | 0 | | 1 | | 1 | | 0 | | 0 | |
|  | | Travancoriana spp. | | 1 | | 1 | | 1 | | 0 | | 0 | |
|  | | Gubernatoriana spp. | | 0 | | 0 | | 0 | | 0 | | 1 | |
|  | | Vanni ashini | | 0 | |  | | 0 | | 1 | | 0 | |
|  | | Paratelphusa spp | | 1 | | 2 | | 2 | | 3 | | 1 | |
|  | | Macrobrachium rosenbergii | | 1 | | 0 | | 1 | | 0 | | 0 | |
|  | | potomon spp. | | 0 | | 1 | | 1 | | 1 | | 0 | |
| Diptera | | Atherix spp. | | 1 | | 1 | | 0 | | 2 | | 1 | |
|  | | Atrichops spp. | | 0 | | 0 | | 0 | | 1 | | 1 | |
|  | | Dasyhelea spp. | | 1 | | 0 | | 0 | | 1 | | 0 | |
|  | | Bezzia spp. | | 0 | | 1 | | 0 | | 0 | | 1 | |
|  | | Chironomus spp. | | 2 | | 1 | | 1 | | 1 | | 0 | |
|  | | Clinotanypus spp. | | 0 | | 0 | | 0 | | 1 | | 0 | |
|  | | Polypedilum spp | | 1 | | 0 | | 0 | | 0 | | 0 | |
|  | | Ablabesmyia spp. | | 1 | | 2 | | 0 | | 1 | | 1 | |
|  | | Culex spp. | | 0 | | 1 | | 1 | | 1 | | 0 | |
|  | | Aedes spp. | | 1 | | 0 | | 0 | | 1 | | 0 | |
|  | | Culiseta spp. | | 0 | | 0 | | 0 | | 1 | | 0 | |
|  | | Limoniid spp. | | 0 | | 1 | | 0 | | 0 | | 1 | |
|  | | Dicranota spp. | | 1 | | 1 | | 0 | | 1 | | 0 | |
|  | | Tabanus spp. | | 1 | | 0 | | 0 | | 1 | | 0 | |
|  | | Sepedon. Spp | | 0 | | 0 | | 0 | | 0 | | 1 | |
| (Continued) | |  | |  | |  | |  | |  | |  | |
| **Order** | **Genus/species** | | **S1** | | **S2** | | **S3** | | **S4** | | **S5** | |
| Ephemeroptera | Baetis spp. | | 0 | | 2 | | 2 | | 1 | | 0 | |
|  | Labiobaetis spp. | | 1 | | 1 | | 1 | | 1 | | 2 | |
|  | Caenis spp. | | 3 | | 3 | | 3 | | 3 | | 3 | |
|  | Ephemera spp. | | 2 | | 2 | | 3 | | 3 | | 3 | |
|  | Isonychia spp. | | 0 | | 1 | | 1 | | 1 | | 0 | |
|  | Choroterpes spp. | | 0 | | 3 | | 1 | | 2 | | 1 | |
|  | Isca spp. | | 0 | | 1 | | 0 | | 0 | | 1 | |
|  | Thraulus spp. | | 1 | | 1 | | 1 | | 0 | | 2 | |
|  | Indialis spp. | | 0 | | 1 | | 1 | | 0 | | 1 | |
| Haplotaxida | Nais spp. | | 0 | | 0 | | 1 | | 0 | | 0 | |
|  | Tubifex spp. | | 0 | | 2 | | 0 | | 1 | | 1 | |
| Hemiptera | Sigara spp. | | 0 | | 2 | | 1 | | 0 | | 1 | |
|  | Pelocoris spp. | | 0 | | 1 | | 1 | | 0 | | 0 | |
|  | Heleocoris spp. | | 0 | | 2 | | 1 | | 0 | | 0 | |
|  | Naucoris sp. | | 1 | | 1 | | 1 | | 1 | | 0 | |
|  | Ranatra spp. | | 0 | | 0 | | 1 | | 0 | | 0 | |
|  | Notonecta spp. | | 1 | | 0 | | 1 | | 1 | | 0 | |
|  | Velia spp. | | 0 | | 0 | | 0 | | 1 | | 0 | |
| Lepidoptera | Acronicta spp. | | 0 | | 0 | | 0 | | 1 | | 0 | |
| Littorinimorpha | Bithynia spp. | | 1 | | 1 | | 0 | | 0 | | 1 | |
| Odonata | Vestalis gracilis | | 0 | | 2 | | 0 | | 0 | | 1 | |
|  | Heliocypha spp. | | 0 | | 1 | | 0 | | 1 | | 1 | |
|  | Pseudagrion spp. | | 0 | | 1 | | 0 | | 1 | | 0 | |
|  | Neoneura spp. | | 2 | | 2 | | 1 | | 3 | | 1 | |
|  | Argia spp. | | 1 | | 3 | | 1 | | 2 | | 1 | |
|  | Ischnura spp. | | 0 | | 0 | | 1 | | 1 | | 0 | |
|  | Cordulegaster spp. | | 0 | | 0 | | 1 | | 1 | | 1 | |
|  | Hemicordulia spp. | | 1 | | 0 | | 1 | | 0 | | 0 | |
|  | Somatochlora spp. | | 0 | | 1 | | 1 | | 0 | | 0 | |
|  | Euphaea spp. | | 1 | | 2 | | 0 | | 1 | | 1 | |
|  | Heliogomphus spp. | | 0 | | 1 | | 0 | | 0 | | 1 | |
|  | Gomphus spp. | | 3 | | 3 | | 3 | | 0 | | 2 | |
|  | Onychogomphus spp | | 0 | | 1 | | 0 | | 0 | | 0 | |
|  | Chlorogomphus spp. | | 0 | | 0 | | 0 | | 1 | | 0 | |
|  | Arigomphus spp. | | 0 | | 1 | | 0 | | 0 | | 0 | |
|  | Paragomphus spp | | 0 | | 1 | | 0 | | 1 | | 0 | |
|  | Hagenius spp. | | 1 | | 0 | | 0 | | 2 | | 2 | |
|  | Sympetrum spp. | | 0 | | 1 | | 1 | | 0 | | 1 | |
|  | Diplacodes spp. | | 0 | | 1 | | 1 | | 0 | | 0 | |
|  | Trithemis spp. | | 0 | | 0 | | 1 | | 1 | | 0 | |
|  | Libellula spp. | | 2 | | 0 | | 2 | | 2 | | 2 | |
|  | Macromia spp. | | 0 | | 1 | | 1 | | 1 | | 1 | |
|  | **(Continued)** | |  | |  | |  | |  | |  | |
| **Order** | **Genus/species** | | **S1** | | **S2** | | **S3** | | **S4** | | **S5** | |
|  | Copera vittate | | 0 | | 1 | | 0 | | 1 | | 1 | |
| Plecoptera | Thallaperla spp. | | 0 | | 1 | | 0 | | 0 | | 1 | |
|  | Perlesta spp. | | 0 | | 0 | | 0 | | 0 | | 1 | |
| Trichoptera | Anisocentropus spp. | | 2 | | 1 | | 0 | | 1 | | 2 | |
|  | Hydropsyche spp. | | 0 | | 0 | | 0 | | 1 | | 1 | |
|  | Limnephilus spp. | | 1 | | 0 | | 0 | | 1 | | 1 | |
|  | Rhyacophila spp. | | 0 | | 2 | | 0 | | 1 | | 1 | |
| Tubificida | Branchiura sowerbyi | | 0 | | 0 | | 1 | | 2 | | 0 | |

**Legend:** S1- Kattila Para, S2- Munkuthu, S3- Man Chal, S4- Onnam Mile, S5- Irrikappara

**Appendix 3.** Order-wise abundance of benthic macroinvertebrates in Kulathupuzha and Shendurney during the study period (2021–2023).

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Architaenioglossa** | **Coleoptera** | **Decapoda** | **Diptera** | **Ephemeroptera** | **Haplotaxida** | **Hemiptera** | **Lepidoptera** | **Littorinimorpha** | **Odonata** | **Plecoptera** | **Trichoptera** |
| S1 | 0 | 286.62 | 95.54 | 222.92 | 191.08 | 63.69 | 63.69 | 0 | 63.69 | 477.7 | 0 | 127.38 |
| S2 | 0 | 222.92 | 222.92 | 286.62 | 573.24 | 31.84 | 127.38 | 0 | 31.84 | 636.64 | 31.84 | 159.23 |
| S3 | 31.84 | 159.23 | 95.54 | 159.23 | 350.31 | 0 | 31.84 | 0 | 31.84 | 350.31 | 0 | 0 |
| S4 | 0 | 286.62 | 63.69 | 477.7 | 350.31 | 0.01 | 95.54 | 0 | 0 | 541.4 | 63.69 | 222.92 |
| S5 | 0 | 0 | 477.7 | 127.38 | 191.08 | 63.69 | 31.84 | 0 | 0 | 286.62 | 31.84 | 0 |
| S6 | 31.84 | 382.16 | 254.77 | 286.62 | 286.62 | 63.69 | 95.54 | 31.84 | 95.54 | 350.31 | 31.84 | 159.23 |
| S7 | 63.69 | 350.31 | 95.54 | 286.63 | 222.92 | 0 | 63.69 | 0 | 31.84 | 350.31 | 0 | 95.54 |
| S8 | 63.69 | 318.47 | 191.08 | 254.77 | 477.7 | 254.77 | 0 | 0 | 31.84 | 732.48 | 31.84 | 95.54 |
| S9 | 0 | 541.4 | 222.92 | 63.69 | 414.01 | 63.69 | 191.08 | 0 | 0 | 477.7 | 0 | 0 |
| S10 | 31.84 | 222.92 | 127.38 | 382.16 | 350.31 | 222.92 | 0.01 | 31.84 | 0 | 605.09 | 0 | 127.38 |
| S11 | 63.69 | 191.08 | 63.69 | 191.08 | 382.16 | 31.84 | 31.84 | 0 | 31.84 | 509.55 | 63.69 | 159.23 |

**Legend:** S1- Mottal Mood, S2- Marappalam, S3- Perum Padappy, S4- Plavu Chal, S5- Pullu Mala, S6- Poovanathu Mood, S7- Kattila Para, S8- Munkuthu, S9- Man Chal, S10- Onnam Mile, S11- Irrikappara