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## FACULTAD DE INGENIERÍA

**Sede Bogotá**

## FORMATO

## REGISTRO ASIGNATURA TRABAJO DE GRADO

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| Favor diligenciar en computador. Modifique el tamaño de los campos de texto según su necesidad.  Para cualquier inquietud remítase al Acuerdo 037 de 2017 del Consejo de Facultad de Ingeniería sede Bogotá:  [**http://www.legal.unal.edu.co/sisjurun/normas/Norma1.jsp?i=88861**](http://www.legal.unal.edu.co/sisjurun/normas/Norma1.jsp?i=88861) |

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| **PROGRAMA CURRICULAR** |  | Ingeniería Civil |  | **FECHA** | DÍA | MES | AÑO |

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| **DATOS DEL ESTUDIANTE** |

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| NOMBRES: David Camilo | | | | | | | APELLIDOS: Gómez Medina |
| TIPO IDENTIFICACIÓN: | T.I. |  | C.C. | X | C.E. |  | NÚMERO: 1026599658 |
| CORREO INSTITUCIÓNAL: dcgomezme@unal.edu.co | | | | | | | TELÉFONO: 3142240708 |

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| **MODALIDAD DE TRABAJO DE GRADO** (Seleccione una opción) |

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| **I. Trabajos investigativos:** 🞏 | **II. Prácticas de extensión:** 🞏 | **III. Asignaturas de postgrado:** 🞏  (Para este caso sólo imprima y diligencie la página 5) |
| a. Trabajo monográfico 🞏 | a. Emprendimiento empresarial 🞏 |
| b. Proyecto final X | b. Pasantía 🞏 |
| c. Participación en proyecto de investigación 🞏 | c. Proyecto social 🞏 |

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| **AVAL DEL DOCENTE DIRECTOR** (En caso de modalidades I o II): |

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| NOMBRES: Leonardo David Donado Garzón | DEPARTAMENTO: Ingeniería Civil y Agrícola |
| CORREO INSTITUCIONAL: lddonadog@unal.edu.co | TELÉFONO-EXT.: |

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| **AVAL DEL DOCENTE CO-DIRECTOR** (En caso de modalidades I o II): |

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| **COMPONENTES** |

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| **1. TÍTULO DEL TRABAJO DE GRADO (**En caso de modalidades I o II)  **Assessment of methodologies to estimate aquifer recharge in the Lebrija River basin** |

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| **2. INTRODUCCIÓN Y JUSTIFICACIÓN** (En caso de modalidades I o II)  An aquifer is a geological structure or natural formation capable of storing and transmitting a certain amount of water and thus supplying a quantity of water to a well or spring (Singhal & Gupta, 2010). In aquifers, it is important to know their recharge, which can be as the flow of water that percolates the soil into the groundwater (Hölting & Coldewey, 2019). Recharge can be influenced by different issues, such as climate, land cover and land use, slope and soil characteristics, and geology; but the most important factor is rainfall (IDEAM, 2019).  The aquifer recharge quantification is of great importance for the management of water resources as an important source of water supply for human consumption and agroindustry activities (IDEAM, 2019). Thus, the understanding of its origin, functioning, relationship with other sources is a crucial issue. In addition, groundwater has the advantage that it has been considered an economical alternative source due to its better quality and relatively low management cost compared to surface water (IDEAM, 2013).  This research is focused on the estimation of groundwater recharge in the Lebrija river basin. The initial part of the research project is to identify methodologies to estimate aquifer recharge based on the available hydrological, geological, soil, slope and hydrometeorological information. Accordingly, the research looks for the identification of the most reliable methodology considering the hydrological conditions of a tropical basin. |

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| **3. OBJETIVO GENERAL** (En caso de modalidades I o II)  To estimate aquifer recharge in the tropical basin based on empirical formulations. |

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| **4. OBJETIVOS ESPECÍFICOS** (En caso de modalidades I o II)   * To identify the main parameters that influence the estimation of the aquifer recharge. * To implement available empirical methodologies to estimate groundwater recharge in the Lebrija basin, Santander. * To identify the most reliable methodology to estimate groundwater recharge in a tropical basin. |

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| **5. ANTECEDENTES** (En caso de modalidad I)  For the estimation of aquifer recharge there are different ways, and according to (Scanlon et al., 2002) it is necessary to consider the spatial and temporal scales, the range and the reliability of the recharge estimates. Techniques are generally classified into physical, tracer, or numerical modeling approaches.  **Water Budget**  In this method, a system of interest is defined and certain processes of the hydrologic cycle determine the outflow and inflow of water into this system. When quantifying system inputs and outputs, the change in storage may be known (Scanlon et al., 2002).  **Techniques based on Surface-Water Studies**  The condition of surface water recharge depends on the degree of connection between surface and groundwater systems. There are physical techniques such as channel-water budget, seepage meters and baseflow discharge; and tracer techniques such as, heat isotopic tracers; and finally, numerical modelling (Scanlon et al., 2002).  **Techniques based on Unsaturated-Zone Studies**  Unsaturated zone techniques for estimating recharge are applied mainly in semi-arid and arid regions, where the unsaturated zone is usually thick. Examples of these techniques are physical techniques such as lysimeters, zero-flux plane and Darcy’s law; tracer techniques such as applied tracers, historical tracers and environmental tracers-chloride; and lastly numerical modelling (Scanlon et al., 2002).  **Techniques based on Saturated-Zone Studies**  Most unsaturated zone techniques produce point estimates of recharge; saturated zone techniques usually integrate on much larger areas. While approaches to surface water and unsaturated areas provide estimates of drainage or potential recharge, approaches to saturated areas provide evidence of real recharge because the water reaches the water table (Scanlon et al., 2002).  **Physical Techniques**  Physical techniques can be the Water Table Fluctuation (WTF) based on the hypothesis that the increase in groundwater levels in unconfined aquifers is due to the recharge of water arriving at the water table. Darcy’s Law, used to estimate the flow in a cross section of an unconfined or confined aquifer. Tracer techniques such as groundwater dating and environmental tracers-chloride. And finally, numerical modeling (Scanlon et al., 2002). |

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| **6. APLICACIÓN Y/O APORTE ESPECÍFICO A LA INGENIERÍA** (En caso de modalidad II) |

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| **7. METODOLOGÍA** (En caso de modalidades I o II (a.) o II (c.))  This research work does not require a specific physical space as long as there is access (in person or remotely) to the equipment where all the work will be developed. This work will be divided into the following phases:  **Phase I - Collection of information**  During this phase, a literature review of empirical methodologies for estimating aquifer recharge will be carried out. In addition, information will be compiled on all the variables necessary to calculate aquifer recharge. This information includes land cover and soil classification, digital elevation model, hydrometeorological information, among others.  **Phase II – Data processing**  During this phase, all the information of the variables necessary for the calculation of aquifer recharge for the different methodologies will be processed. To do this, Excel will be used to debug the information, QGIS will be used to process the geospatial information, and finally, the R programming language will be used to create the map algebra.  **Phase III - Implementation recharge calculation methodologies**  With the information about the different variables collected and processed, the guidelines of the different methodologies are followed to obtain the different results of potential aquifer recharge.  **Phase IV - Analysis of the results**  Based on the results of the potential recharge of aquifers, the research will provide an analysis and comparison of the different methodologies, the implications of the considered variables and the implications of the implementation of these methodologies.  **Phase V - Conclusions and presentation of results**  The analysis and details of the research will be compiled to consolidate the conclusions and make the presentation of the results to the Universidad Nacional de Colombia through the document of the final undergraduate work with its respective support. |

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| **8. RECURSOS** (En caso de modalidad I) |

**9. CRONOGRAMA DE ACTIVIDADES** (En caso de modalidades I o II)

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|  | **Semanas de ejecución de cada actividad** | | | | | | | | | | | | | | | |
| **ACTIVIDADES A REALIZAR** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** |
| Revisión de literatura |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Tratamiento preliminar de datos |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Estimación de la recarga de acuíferos |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Elaboración del álgebra de mapas de la recarga de acuíferos |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Evaluación de las metodologías de estimación de recarga de acuíferos |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Elaboración del documento |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

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| **10. PRESUPUESTO Y FUENTES DE FINANCIACIÓN** (En caso de modalidad I)  En la siguiente tabla se detallan los recursos proyectados para el desarrollo de la investigación.   |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | **Capítulo** | **Rubro** | **Fuente** | **Unidad** | **Cantidad** | **Valor unitario** | **Valor total** | | **Personal** | Director | UNAL | HORAS | 32 | $ 50.000,00 | $ 1.600.000,00 | | Codirector | UNAL | HORAS | 32 | $ 400.000,00 | $ 12.800.000,00 | | Proponente | PROPIOS | MES | 320 | $ 300.000,00 | $ 96.000.000,00 | | **SUBTOTAL CAPÍTULO** | | | | | $ 110.400.000,00 | | **Servicios e insumos** | Internet | UNAL | MES | 6 | $ 100.000,00 | $ 600.000,00 | | Suministros de oficina | UNAL | GLOBAL | 1 | $ 250.000,00 | $ 250.000,00 | | Biblioteca y servicios de consulta | UNAL | GLOBAL | 1 | $ 70.000,00 | $ 70.000,00 | | **SUBTOTAL CAPÍTULO** | | | | | $ 920.000,00 | | **Equipos** | Software | UNAL | GLOBAL | 1 | $ 1.800.000,00 | $ 1.800.000,00 | | Computador | UNAL | GLOBAL | 1 | $ 1.000.000,00 | $ 1.000.000,00 | | Impresora | UNAL | GLOBAL | 1 | $ 315.000,00 | $ 315.000,00 | | **SUBTOTAL CAPÍTULO** | | | | | $ 3.115.000,00 | | **Locativos** | Espacio en oficina | UNAL | MES | 6 | $ 200.000,00 | $ 1.200.000,00 | | **SUBTOTAL CAPÍTULO** | | | | | $ 1.200.000,00 | | **TOTAL** | | | | | | $ 115.635.000,00 | |

**11. CRITERIOS DE EVALUACIÓN** (En caso de modalidades I o II)

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| **CRITERIOS DE EVALUACIÓN** | **Porcentaje del criterio** |
| Primer informe de avance | 20 % |
| Segundo informe de avance | 20 % |
| Tercer informe de avance | 20 % |
| Documento final | 20 % |
| Sustentación | 20 % |

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| **12. RESULTADOS ESPERADOS** (En caso de modalidades I o II (a.) o II (c.))  Evaluate the different methodologies selected and identify the appropriate one for estimating aquifer recharge in the study area. In addition, publish the result obtained through a research article. |

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| **13. BIBLIOGRAFÍA** (En caso de modalidad I)   * Hölting, B., & Coldewey, W. G. (2019). Hydrogeology. Springer. https://doi.org/https://doi.org/10.1007/978-3-662-56375-5 * Singhal, B., & Gupta, R. (2010). Applied Hydrogeology of Fractured Rocks, Second Edition. Springer. https://doi.org/10.1007/978-90-481-8799-7 * IDEAM (2019). Estudio Nacional del Agua 2018. Bogotá: Ideam: 452 pp. * IDEAM. Aguas Subterráneas en Colombia: una Visión General. Bogotá D. C., 2013. 284 págs. * Scanlon, B. R., Healy, R. W., Scanlon, B. R., Healy, R. W., & Cook, P. G. (2002). Choosing appropriate techniques for quantifying groundwater recharge. Hydrogeology Journal, 10, 18–39. https://doi.org/10.1007/s10040-0010176-2 |

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| **14. DATOS DE LA ORGANIZACIÓN** (En caso de modalidades II (b.) o II (c.)) | | |
| NOMBRE DE LA ORGANIZACIÓN: | | |
| RESPONSABLE DE LA ORGANIZACIÓN: | | |
| CORREO: | TELÉFONO: | DURACIÓN VINCULACIÓN (semanas): |

*(Art. 6 – Parágrafo 1 – Acuerdo 037 de 2017 del Consejo de Facultad de Ingeniería sede Bogotá)*. Si alguno(s) de los componentes del documento soporte de la inscripción del Trabajo de Grado en la modalidad Prácticas de Extensión no está disponible en el momento de la solicitud de la inscripción, es decir antes de finalizar la semana catorce del periodo académico anterior al cual el estudiante aspire a realizar el Trabajo de Grado, se deberá explicar el motivo por el cual no está(n) disponible(s) y anexar los componentes faltantes junto con una solicitud de formalización de la inscripción del trabajo de grado presentada al Comité Asesor del Programa Curricular, antes de la semana ocho del semestre académico en que va a cursar la asignatura Trabajo de Grado en la modalidad Prácticas de Extensión.

*(Art. 6 – Parágrafo 3 – Acuerdo 037 de 2017 del Consejo de Facultad de Ingeniería sede Bogotá)*. En caso de la modalidad II (b.) Pasantía, el estudiante deberá presentar ante el Comité Asesor del Programa Curricular, el documento del convenio vigente o la carta de intención o el acuerdo de voluntades, entre la Universidad Nacional de Colombia y la organización con la que se desarrollará la *Práctica de* *Extensión*

**15. ASIGNATURAS QUE ASPIRA INSCRIBIR** (En caso de modalidad III)

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| **NOMBRE** | **CÓDIGO SIA** | **CRÉDITOS** | **PROGRAMA QUE LA OFRECE** |
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Total de créditos: \_\_\_\_\_\_

**16. FIRMAS**

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| **FIRMA DEL ESTUDIANTE:** | **FIRMA DEL DOCENTE DIRECTOR** (En caso de modalidades I o II): |
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| **FIRMA DEL ESTUDIANTE:** | **FIRMA DEL DOCENTE CO-DIRECTOR** (En caso de modalidades I o II): |
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**17. DATOS DE TRÁMITE COMITÉ ASESOR DE PROGRAMA** (Espacio para diligenciar por el Comité Asesor de Programa)

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| **No. CONSECUTIVO** |  |
| **No. ACTA** |  |
| **FECHA** |  |