TOMSK POLYTECHNIC UNIVERSITY — ТОМСКИЙ ПОЛИТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ

Министерство науки и высшего образования Российской Федерации
федеральное государственное автономное
образовательное учреждение высшего образования
«Национальный исследовательский Томский политехнический университет» (ТПУ)

Инженерная школа ядерных технологий
Направление подготовки 14.03.02 Ядерные физика и технологии
Отделение ядерно-топливного цикла

# БАКАЛАВРСКАЯ РАБОТА

| Тема работы |
|---|
| **Уровни гамма - фона в парках и зонах отдыха г. Томска** |

УДК 539.122.16: 712.2 (571.16)

Студент

| Группа | ФИО | Подпись | Дата |
|---|---|---|---|
| 0А7А | Сацук Дмитрий Владимирович | | |

Руководитель ВКР

| Должность | ФИО | Ученая степень, звание | Подпись | Дата |
|---|---|---|---|---|
| Профессор ОЯТЦ | Яковлева Валентина Станиславовна | д.т.н | | |

Консультант

| Должность | ФИО | Ученая степень, звание | Подпись | Дата |
|---|---|---|---|---|
| Старший преподаватель ОЯТЦ | Побережников Андрей Дмитриевич | - | | |

## КОНСУЛЬТАНТЫ ПО РАЗДЕЛАМ:

По разделу «Финансовый менеджмент, ресурсоэффективность и ресурсосбережение»

| Должность | ФИО | Ученая степень, звание | Подпись | Дата |
|---|---|---|---|---|
| Профессор ОСГН ШИП | Гасанов М.А | д.э.н. | | |

По разделу «Социальная ответственность»

| Должность | ФИО | Ученая степень, звание | Подпись | Дата |
|---|---|---|---|---|
| Доцент ОЯТЦ ИЯТШ | Передерин Ю.В | к.т.н. | | |

## ДОПУСТИТЬ К ЗАЩИТЕ:

| Руководитель ООП | ФИО | Ученая степень, звание | Подпись | Дата |
|---|---|---|---|---|
| Доцент ОЯТЦ ИЯТШ | Бычков П.Н | к.т.н. | | |

Томск – 2021 г.

Министерство науки и высшего образования Российской Федерации
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образовательное учреждение высшего образования
«Национальный исследовательский Томский политехнический университет» (ТПУ)

School of Nuclear Science & Engineering
Field of training (specialty): 14.03.02 Nuclear Science and Technology
Specialization: Radiation safety of humans and the environment
Nuclear Fuel Cycle Division

**BACHELOR THESIS**

| **Topic of research work** |
|---|
| **Gamma background levels in parks and recreation areas of Tomsk** |

UDC_539.122.16: 712.2 (571.16)

Student

| **Group** | **Full name** | **Signature** | **Date** |
|---|---|---|---|
| 0A7A | Satsuk D.V. | | |

Scientific supervisor

| **Position** | **Full name** | **Academic degree, academic rank** | **Signature** | **Date** |
|---|---|---|---|---|
| Professor of NFCF | Yakovleva V.S | Professor, PhD | | |

Консультант

| Position | Full name | Academic degree, academic rank | Signature | Date |
|---|---|---|---|---|
| Senior lecturer of NFCF | Poberezhnikov A.D. | - | | |

**ADVISERS:**

Section "Financial Management, Resource Efficiency and Resource Saving"

| **Position** | **Full name** | **Academic degree, academic rank** | **Signature** | **Date** |
|---|---|---|---|---|
| Professor | Hasanov M.A | PhD | | |

Section "Social Responsibility"

| **Position** | **Full name** | **Academic degree, academic rank** | **Signature** | **Date** |
|---|---|---|---|---|
| Associate Professor | Perederin Y.V. | PhD | | |

**ADMITTED TO DEFENSE:**

| **Programme Director** | **Full name** | **Academic degree, academic rank** | **Signature** | **Date** |
|---|---|---|---|---|
| Associate Professor | Bychkov P.N. | PhD | | |

Tomsk – 2021

**ПЛАНИРУЕМЫЕ РЕЗУЛЬТАТЫ ОСВОЕНИЯ ООП**

| Код компетенции | Наименование компетенции |
|---|---|
| **Универсальные компетенции** | |
| **УК(У)-1** | Способен осуществлять поиск, критический анализ и синтез информации, применять системный подход для решения поставленных задач |
| **УК(У)-2** | Способен определять круг задач в рамках поставленной цели и выбирать оптимальные способы их решения, исходя из действующих правовых норм, имеющихся ресурсов и ограничений |
| **УК(У)-3** | Способен осуществлять социальное взаимодействие и реализовывать свою роль в команде |
| **УК(У)-4** | Способен осуществлять деловую коммуникацию в устной и письменной формах на государственном и иностранном (-ых) языке |
| **УК(У)-5** | Способен воспринимать межкультурное разнообразие общества в социально-историческом, этическом и философском контекстах |
| **УК(У)-6** | Способен управлять своим временем, выстраивать и реализовывать траекторию саморазвития на основе принципов образования в течение всей жизни |
| **УК(У)-7** | Способен поддерживать должный уровень физической подготовленности для обеспечения полноценной социальной и профессиональной деятельности |
| **УК(У)-8** | Способен создавать и поддерживать безопасные условия жизнедеятельности, в том числе при возникновении чрезвычайных ситуаций |
| **Общепрофессиональные компетенции** | |
| **ОПК(У)-1** | способностью использовать основные законы естественнонаучных дисциплин в профессиональной деятельности, применять методы математического анализа и моделирования, теоретического и экспериментального исследования |
| **ОПК(У)-2** | способностью понимать сущность и значение информации в развитии современного информационного общества, сознавать опасности и угрозы, возникающие в этом процессе, соблюдать основные требования информационной безопасности, в том числе защиты государственной тайны |
| **ОПК(У)-3** | владением основными методами защиты производственного персонала и населения от возможных последствий аварий, катастроф, стихийных бедствий |
| **Профессиональные компетенции** | |
| **ПК(У)-1** | способностью использовать научно-техническую информацию, отечественный и зарубежный опыт по тематике исследования, современные компьютерные технологии и информационные ресурсы в своей предметной области |
| **ПК(У)-2** | способностью проводить математическое моделирование процессов и объектов на базе стандартных пакетов автоматизированного проектирования и исследований |
| **ПК(У)-3** | готовностью к проведению физических экспериментов по заданной методике, составлению описания проводимых исследований и анализу результатов |

| | |
|---|---|
| **ПК(У)-4** | способностью использовать технические средства для измерения основных параметров объектов исследования, к подготовке данных для составления обзоров, отчетов и научных публикаций |
| **ПК(У)-5** | готовностью к составлению отчета по выполненному заданию, к участию во внедрении результатов исследований и разработок |
| **ПК(У)-6** | способностью использовать информационные технологии при разработке новых установок, материалов и приборов, к сбору и анализу исходных данных для проектирования приборов и установок |
| **ПК(У)-7** | способностью к расчету и проектированию деталей и узлов приборов и установок в соответствии с техническим заданием с использованием стандартных средств автоматизации проектирования |
| **ПК(У)-8** | готовностью к разработке проектной и рабочей технической документации, оформлению законченных проектно-конструкторских работ |
| **ПК(У)-9** | способностью к контролю соответствия разрабатываемых проектов и технической документации стандартам, техническим условиям, требованиям безопасности и другим нормативным документам |
| **ПК(У)-10** | готовностью к проведению предварительного технико-экономического обоснования проектных решений при разработке установок и приборов |
| **ПК(У)-12** | способностью к контролю за соблюдением технологической дисциплины и обслуживанию технологического оборудования |
| **ПК(У)-13** | способностью к организации метрологического обеспечения технологических процессов, к использованию типовых методов контроля качества выпускаемой продукции |
| **ПК(У)-14** | готовностью к эксплуатации современного физического оборудования и приборов, к освоению технологических процессов в ходе подготовки производства новых материалов, приборов, установок и систем |
| **ПК(У)-15** | способностью к монтажу, наладке, настройке, регулировке, испытанию и сдаче в эксплуатацию оборудования и программных средств |
| **ПК(У)-17** | способностью к оценке ядерной и радиационной безопасности, к оценке воздействия на окружающую среду, к контролю за соблюдением экологической безопасности, техники безопасности, норм и правил производственной санитарии, пожарной, радиационной и ядерной безопасности, норм охраны труда |
| **ПК(У)-18** | готовностью разрабатывать способы применения ядерно-энергетических, плазменных, лазерных, сверхвысокочастотных и мощных импульсных установок, электронных, нейтронных и протонных пучков, методов экспериментальной физики в решении технических, технологических и медицинских проблем |
| **ПК(У)-20** | способностью к составлению технической документации (графиков работ, инструкций, планов, смет, заявок на материалы, оборудование), а также установленной отчетности по утвержденным формам |

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образовательное учреждение высшего образования
«Национальный исследовательский Томский политехнический университет» (ТПУ)

Школа инженерная школа ядерных технологий
Направление подготовки 14.03.02 Ядерные физика и технологии
Отделение школы отделение ядерно-топливного цикла

УТВЕРЖДАЮ:
Руководитель ООП
_____ _______ Бычков П.Н.
(Подпись) (Дата) (Ф.И.О.)

**ЗАДАНИЕ**
**на выполнение выпускной квалификационной работы**

В форме:

| |
|---|
| бакалаврской работы |

Студенту:

| Группа | ФИО |
|---|---|
| 0А7А | Сацук Дмитрий Владимирович |

Тема работы:

| | |
|---|---|
| Уровни гамма - фона в парках и зонах отдыха г. Томска | |
| Утверждена приказом директора (дата, номер) | 28.04.2021 г., №118-33/с |

| | |
|---|---|
| Срок сдачи студентом выполненной работы: | 09.06.2021 |

**ТЕХНИЧЕСКОЕ ЗАДАНИЕ:**

| | |
|---|---|
| **Исходные данные к работе** | Исследование изменения радиационного фона от объектов техносферы в городской среде. Фоновое излучение исследовалось с помощью трех детекторов: широкодиапазонного дозиметра ДРГ-01Т1, дозиметра-радиометра ДРБП-03, сцинтилляционного детектора на базе пластикового сцинтиллятора ВС-408, предварительно откалиброванных с помощью источника $Cs^{137}$. |

| | |
|---|---|
| **Перечень подлежащих исследованию, проектированию и разработке вопросов** | - Обзор литературных источников<br>- Выбор измерительных приборов<br>- Проведение измерений уровня гамма-фона в выбранных локациях города Томска<br>- Анализ и описание результатов<br>-Финансовый менеджмент, ресурсоэффективность и ресурсосбережение;<br>- Социальная ответственность;<br>- Заключение по работе. |
| **Перечень графического материала** | Презентация для защиты ВКР |

**Консультанты по разделам выпускной квалификационной работы**

| Раздел | Консультант |
|---|---|
| Социальная ответственность | Передерин Ю.В. |
| Финансовый менеджмент, ресурсоэффективность и ресурсосбережение | Гасанов М.А. |

| | |
|---|---|
| **Дата выдачи задания на выполнение выпускной квалификационной работы по линейному графику** | 26.04.2021 |

**Задание выдал руководитель / консультант (при наличии):**

| Должность | ФИО | Ученая степень, звание | Подпись | Дата |
|---|---|---|---|---|
| Профессор ОЯТЦ | Яковлева Валентина Станиславовна | д.т.н | | |
| Старший преподаватель ОЯТЦ | Побережников Андрей Дмитриевич | - | | |

**Задание принял к исполнению студент:**

| Группа | ФИО | Подпись | Дата |
|---|---|---|---|
| 0А7А | Сацук Дмитрий Владимирович | | |

TOMSK POLYTECHNIC UNIVERSITY
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образовательное учреждение высшего образования
«Национальный исследовательский Томский политехнический университет» (ТПУ)

School of Nuclear Science & Engineering
Field of training (specialty): 14.03.02 Nuclear Science and Technology
Specialization: Radiation safety of humans and the environment
Nuclear Fuel Cycle Division

APPROVED BY:
Program Director
_____________ Bychkov P.N.
«____» ____________ 2021

**ASSIGNMENT**
**for the Graduation Thesis completion**

In the form:

| |
|---|
| Bachelor Thesis |

For a student:

| Group | Full name |
|---|---|
| 0A7A | Satsuk Dmitriy Vladimirovich |

Topic of research work:

| | |
|---|---|
| Gamma background levels in parks and recreation areas of Tomsk | |
| Approved by the order of the Director of School of Nuclear Science & Engineering (date, number): | 28.04.2021 г., №118-33/с |

| | |
|---|---|
| Deadline for completion of Bachelor Thesis: | 09.06.2021 |

**TERMS OF REFERENCE:**

| | |
|---|---|
| Initial date for research work: | Investigation of changes in the radiation background from objects of the technosphere in the urban environment. Background radiation was investigated using three detectors: a wide-range DRG-01T1 dosimeter, the dosimeter radiometer DRBP-03 scintillation detector based BC-408 plastic scintillator precalibrated using Cs137 source. |

| | |
|---|---|
| List of the issues to be investigated, designed and developed | – To review the literature<br>– To formulate the goals and objectives of the study<br>– To Measure gamma background radiation in urban environment.<br>– To Calculate of radiation doses<br>– To compare calculated radiation dose with recommended safe limits and world average values<br>– Analysis of the results;<br>– Financial management, resource efficiency and resource conservation;<br>– Social responsibility;<br>– Conclusion |
| List of graphic material | Presentation for the defense of the FQP |

Advisors to the sections of the Bachelor Thesis

| Section | Advisor |
|---|---|
| Social Responsibility | Perederin Yuri Vladimirovich |
| Financial Management, Resource Efficiency and Resource Saving | Hasanov Maharram Ali oglu |

| | |
|---|---|
| Date of issuance of the assignment for Bachelor Thesis completion according to the schedule | 26.04.2021 |

**Assignment issued by a scientific supervisor / advisor (if any):**

| Position | Full name | Academic degree, academic status | Signature | Date |
|---|---|---|---|---|
| Professor of NSFD | V.S. Yakovleva | Professor, PhD | | |
| Senior Lecturer | A.D. Poberezhnikov | | | |

**Assignment accepted for execution by a student:**

| Group | Full name | Signature | Date |
|---|---|---|---|
| 0A7A | Satsuk Dmitriy Vladimirovich | | |

**ЗАДАНИЕ ДЛЯ РАЗДЕЛА**
**«ФИНАНСОВЫЙ МЕНЕДЖМЕНТ, РЕСУРСОЭФФЕКТИВНОСТЬ И РЕСУРСОСБЕРЕЖЕНИЕ»**

Студенту:

| Группа | ФИО |
|---|---|
| 0А7А | Сацук Дмитрий Владимирович |

| | | | |
|---|---|---|---|
| **Школа** | ИЯТШ | **Отделение школы (НОЦ)** | ОЯТЦ |
| **Уровень образования** | Бакалавриат | **Направление/специальность** | 14.03.02 Ядерные физика и технологии |

| **Исходные данные к разделу «Финансовый менеджмент, ресурсоэффективность и ресурсосбережение»:** | |
|---|---|
| *1. Стоимость ресурсов научного исследования (НИ): материально-технических, энергетических, финансовых, информационных и человеческих* | *Затраты на спецоборудование 12025руб.*<br>*Заработная плата исполнителей 274036 руб .*<br>*Отчисления во внебюджетные фонды 32883 руб.*<br>*Накладные расходы 92076 руб.*<br>*Прочие прямые затраты 348 руб.* |
| *2. Нормы и нормативы расходования ресурсов* | *Районный коэффициент города Томска – 1,3* |
| *3. Используемая система налогообложения, ставки налогов, отчислений, дисконтирования и Кредитования* | *Размер отчислений во внебюджетные фонды – 30,2 %* |
| **Перечень вопросов, подлежащих исследованию, проектированию и разработке:** | |
| *1. Оценка коммерческого и инновационного потенциала НТИ* | *Оценочная карта конкурентных технических решений. SWOT-анализ.* |
| *2. Планирование процесса управления НТИ: структура и график проведения, бюджет, риски и организация закупок* | *Составление календарного плана проекта.*<br>*Определение бюджета НТИ.* |
| *3. Определение ресурсной, финансовой, экономической эффективности* | *Интегральный финансовый показатель.*<br>*Интегральный показатель ресурсоэффективности.*<br>*Интегральный показатель эффективности.* |
| **Перечень графического материала** | |
| 1. *Оценка конкурентоспособности технических решений*<br>2. *Матрица SWOT*<br>3. *График проведения НТИ*<br>4. *Бюджет НТИ*<br>5. *Оценка ресурсной, финансовой и экономической эффективности НТИ* | |

| **Дата выдачи задания для раздела по линейному графику** | |
|---|---|

**Задание выдал консультант:**

| Должность | ФИО | Ученая степень, звание | Подпись | Дата |
|---|---|---|---|---|
| Профессор ОСГН | Гасанов М.А. | д.э.н. | | |

**Задание принял к исполнению студент:**

| Группа | ФИО | Подпись | Дата |
|---|---|---|---|
| 0А7А | Сацук Дмитрий Владимирович | | |

**TASK FOR SECTION**
**«FINANCIAL MANAGEMENT, RESOURCE EFFICIENCY AND RESOURCE SAVING»**

To the student:

| Group | Full name |
|---|---|
| 0A7A | Satsuk Dmitriy Vladimirovich |

| | | | |
|---|---|---|---|
| **School** | Nuclear Science and Engineering | **Division** | Nuclear Fuel Cycle |
| **Degree** | Bachelor | **Educational Program** | Nuclear physics and technologies |

| **Input data to the section «Financial management, resource efficiency and resource saving»:** | |
|---|---|
| *1. Resource cost of scientific and technical research (STR): material and technical, energetic, financial and human* | *Special equipment costs 12025 rub.*<br>*Basic salary of STR performers 274036 rub.*<br>*Additional salary for theme performers 32883 rub.*<br>*Contributions to extrabudgetary funds 92690 rub.*<br>*Overhead costs 92076 rub.*<br>*Other direct costs 348 rub.* |
| *2. Expenditure rates and expenditure standards for resources* | *Regional coefficient of the city of Tomsk -1,3* |
| *3. Current tax system, tax rates, charges rates, discounting rates and interest rates* | *Amount of contributions to extrabudgetary funds – 30%.* |
| **The list of subjects to study, design and develop:** | |
| *1. Assessment of commercial and innovative potential of STR* | *Competitive technical solutions scorecard* |
| *2. Scheduling of STR management process: structure and timeline, budget, risk management and organization of purchases* | *Creation of the time schedule of the project. Calculation of STR budget.* |
| *3. Determination of resource, financial, economic efficiency* | *Assessing the economic efficiency of using all three types of visualization to control the effectiveness of the method* |
| **A list of graphic material** *(with list of mandatory blueprints):* | |
| *1. "Portrait" of the consumer of STR results*<br>*2. Assessment of the competitiveness of technical solutions*<br>*3. SWOT Matrix*<br>*4. Schedule and budget of STR*<br>*5. Assessment of resource, financial and economic efficiency of STR* | |

| | |
|---|---|
| **Date of issue of the task for the section according to the schedule** | |

**Task issued by adviser:**

| Position | Full name | Scientific degree, rank | Signature | Date |
|---|---|---|---|---|
| Professor | M.A. Gasanov | PhD | | |

**The task was accepted by the student:**

| Group | Full name | Signature | Date |
|---|---|---|---|
| 0A7A | Satsuk Dmitriy Vladimirovich | | |

**ЗАДАНИЕ ДЛЯ РАЗДЕЛА**
**«СОЦИАЛЬНАЯ ОТВЕТСТВЕННОСТЬ»**

| руппа | ФИО |
|---|---|
| 0А7А | Сацук Дмитрий Владимирович |

| | | | |
|---|---|---|---|
| **Институт** | ИЯТШ | **Отделение (НОЦ)** | ОЯТЦ |
| **Уровень образования** | Бакалавриат | **Направление/специальность** | 14.03.02 Ядерные физика и технологии |

Тема ВКР:

| | |
|---|---|
| Уровни гамма - фона в парках и зонах отдыха г. Томска | |
| **Исходные данные к разделу «Социальная ответственность»:** | |
| 1. Характеристика объекта исследования (вещество, материал, прибор, алгоритм, методика, рабочая зона) и области его применения | Объектом исследования является радиационного фон вблизи объектов техносферы в городской среде. |
| Перечень вопросов, подлежащих исследованию, проектированию и разработке: | |
| **1. Правовые и организационные вопросы обеспечения безопасности** | Трудовой кодекс Российской Федерации от 30.12.2001 № 197-ФЗ (ред. от 30.04.2021). |
| **2. Производственная безопасность:**<br>– Анализ выявленных вредных и опасных факторов<br>– Обоснование мероприятий по снижению воздействия | Вредные и опасные факторы:<br>– параметры микроклимата;<br>– повышенный уровень ионизирующих излучений;<br>– вредные вещества;<br>– вентиляция;<br>– шум;<br>– недостаток естественного и искусственного освещения;<br>– электрический ток;<br>– электромагнитные поля;<br>– пожароопасность. |
| **3. Безопасность в чрезвычайных ситуациях** | – падение с высоты собственного роста;<br>– удар электрическим током;<br>– пожар. |

| | |
|---|---|
| **Дата выдачи задания для раздела по линейному графику** | |

**Задание выдал консультант:**

| Должность | ФИО | Ученая степень, звание | Подпись | Дата |
|---|---|---|---|---|
| Доцент ОЯТЦ | Передерин Ю.В. | к.т.н. | | |

**Задание принял к исполнению студент:**

| Группа | ФИО | Подпись | Дата |
|---|---|---|---|
| 0А7А | Сацук Дмитрий Владимирович | | |

## Task for section
## «Social responsibility»

To student:

| Group | Full name |
|---|---|
| 0A7A | Satsuk Dmitriy Vladimirovich |

| | | | |
|---|---|---|---|
| School | Nuclear Science and Engineering | Division | Nuclear Fuel Cycle |
| Degree | Bachelor | Educational Program | 14.03.02 Nuclear physics and technologies/ Radiation safety of humans and the environment |

Topic of research work:

| Gamma background levels in parks and recreation areas of Tomsk | |
|---|---|
| Initial data for section «Social Responsibility»: | |
| 1. Information about object of investigation (matter, material, device, algorithm, procedure, workplace) and area of its application | Measurement of the radiation background of the surface atmosphere and carrying out various types of analysis. |
| List of items to be investigated and to be developed: | |
| **1.** Legal and organizational issues to provide safety:<br>- Special (specific for operation of objects of investigation, designed workplace) legal rules of labor legislation;<br>- Organizational activities for layout of workplace. | - GOST 12.2.032-78 SSBT. Workplace when performing work while sitting. General ergonomic requirements;<br>- GOST R 50923-96. Displays. Operator's workplace. General ergonomic and working environment requirements. Measurement methods;<br>- PND F 12.13.1-03. Guidelines. Safety precautions when working in analytical laboratories (general provisions). |
| **2.** Work Safety:<br>2.1. Analysis of identified harmful and dangerous factors<br>2.2. Justification of measures to reduce probability of harmful and dangerous factors | – deviation of microclimate parameters;<br>– increased noise level;<br>– increased vibration level;<br>– insufficient light<br>– electromagnetic fields;<br>– psychophysiological stress;<br>– electric current. |
| 3. Ecological safety: | – environmental impact of research; |
| 4. Safety in emergency situations: | - selection and description of a typical emergency - fire in the working room;<br>- preventive measures and procedures in case of emergency. |

| **Assignment date for section according to schedule** | |
|---|---|

**The task was issued by consultant:**

| Position | Full name | Scientific degree, rank | Signature | Date |
|---|---|---|---|---|
| Assistant professor | Yu. V. Perederin | Cand.of Sc. | | |

**The task was accepted by the student:**

| Group | Full name | Signature | Date |
|---|---|---|---|
| 0A7A | Satsuk Dmitriy Vladimirovich | | |

TOMSK POLYTECHNIC UNIVERSITY — ТОМСКИЙ ПОЛИТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ

Министерство науки и высшего образования Российской Федерации
федеральное государственное автономное
образовательное учреждение высшего образования
«Национальный исследовательский Томский политехнический университет» (ТПУ)

Школа инженерная школа ядерных технологий
Направление подготовки 14.03.02 Ядерные физика и технологии
Уровень образования бакалавриат
Отделение школы отделение ядерно-топливного цикла
Период выполнения весенний семестр 2020 /2021 учебного года

Форма представления работы:

| Бакалаврская работа |
|---|

**КАЛЕНДАРНЫЙ РЕЙТИНГ-ПЛАН**
**выполнения выпускной квалификационной работы**

| Срок сдачи студентом выполненной работы: | 08.06.2021 |
|---|---|

| Дата контроля | Название раздела (модуля) / вид работы (исследования) | Максимальный балл раздела (модуля) |
|---|---|---|
| 29.04.2021 | Формирование целей и задач ВКР, задания на ВКР, плана-графика выполнения ВКР и титульного листа | 10 |
| 10.05.2021 | Обзор литературных источников | 10 |
| 12.05.2021 | Подготовка и калибровка измерительных приборов | 10 |
| 14.05.2021 | Проведение измерений уровня гамма-фона в выбранных локациях города Томска | 10 |
| 25.05.2021 | Анализ и описание результатов | 10 |
| 3.06.2021 | Финансовый менеджмент, ресурсоэффективность и ресурсосбережение | 15 |
| 3.06.2021 | Социальная ответственность | 15 |
| 7.06.2021 | Заключение по работе | 10 |
| 8.06.2021 | Представление итогового варианта пояснительной записки к ВКР | 10 |

**СОСТАВИЛ:**

**Руководитель ВКР**

| Должность | ФИО | Ученая степень, звание | Подпись | Дата |
|---|---|---|---|---|
| Профессор ОЯТЦ | Яковлева Валентина Станиславовна | д.т.н | | |

**Консультант**

| Должность | ФИО | Ученая степень, звание | Подпись | Дата |
|---|---|---|---|---|
| Старший преподаватель ОЯТЦ | Побережников Андрей Дмитриевич | - | | |

**СОГЛАСОВАНО:**

**Руководитель ООП**

| Должность | ФИО | Ученая степень, звание | Подпись | Дата |
|---|---|---|---|---|
| Доцент ОЯТЦ | Бычков П.Н. | К.т.н. | | |

TOMSK POLYTECHNIC UNIVERSITY
ТОМСКИЙ ПОЛИТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ

Министерство науки и высшего образования Российской Федерации
федеральное государственное автономное
образовательное учреждение высшего образования
«Национальный исследовательский Томский политехнический университет» (ТПУ)

School of Nuclear Science & Engineering
Field of training (specialty): 14.03.02 Nuclear Science and Technology
Specialization: Radiation safety of humans and the environment
Level of education: Bachelor degree programs
Nuclear Fuel Cycle Division
Period of completion: spring semester 2020/2021 academic year

Form of presenting the work:

| Bachelor Thesis |
|---|

**SCHEDULED ASSESSMENT CALENDAR**
**for the Master Thesis completion**

| Deadline for completion of Bachelor's Graduation Thesis: | 08.06.2021 |
|---|---|

| Assessment date | Title of section (module) / type of work (research) | Maximum score for the section (module) |
|---|---|---|
| 29.04.2021 | Formation of the goals and objectives of the FQP, assignments for the FQP, the schedule for the implementation of the FQP and the title page; | 10 |
| 10.05.2021 | Literature Review and Methodology | 10 |
| 12.05.2021 | Preparation and calibration of measuring instruments | 10 |
| 14.05.2021 | Data collection | 10 |
| 25.05.2021 | Analysis of the obtained experimental data | 10 |
| 3.06.2021 | Financial Management, Resource Efficiency and Resource Saving | 15 |
| 3.06.2021 | Social Responsibility | 15 |
| 7.06.2021 | Conclusion on work | 10 |
| 8.06.2021 | Defense preparation | 10 |

**COMPILED BY:**

**Scientific supervisor:**

| Position | Full name | Academic degree, academic status | Signature | Date |
|---|---|---|---|---|
| Professor of NSFD | V.S. Yakovleva | Professor, PhD | | |

**Advisor**

| Position | Full name | Academic degree, academic status | Signature | Date |
|---|---|---|---|---|
| Senior Lecturer | A.D. Poberezhnikov | - | | |

**APPROVED BY:**

| Program Director | Full name | Academic degree, academic status | Signature | Date |
|---|---|---|---|---|
| Assistant professor | Bychkov P.N. | Ph.D. | | |

**Abstract**

Final qualifying work 96 p., 34 figures, 33 tables, 28 sources.

Key words: gamma background, detector, dosimeter, technosphere, radiation, dose rate.

The objective of this study is to investigate changes in gamma background due to Technosphere objects in the urban environment.

In the course of the work, a literary review was carried out, which makes it possible to evaluate the methods and results of similar measurements carried out in other cities of Russia. Dosimetric devices designed to measure the level of gamma background and used in this work, have been studied.

A series of measurements were carried out at points located in the immediate vicinity of the objects of the technosphere and at some distance from these objects. The following instruments were used for measurements: wide-range dosimeter DRG – 01T1, dosimeter-radiometer DRBP – 03 and scintillation detector based on a plastic scintillator BC-408.

The maximum values of the measured power of the subscriber equivalent dose of gamma radiation were 0.27 μSv / h, 0.22 μSv / h, 0.28 μSv / h. In some areas, there is an increased gamma background. Average ADR values for the studied areas were: for the granite embankment 0.191 μSv / h, for the monument "400 years of Tomsk" 0.089 μSv / h, in the Karl Marx square 0.108 μSv / h and on the embankment of the river. Tom 0.119 μSv / h.

The study found that the selected zone does not have a direct radiological impact on public health, but there is a very high probability of developing cancer in humans residing in these areas more than 4.8 hours per day.

Application areas: Environmental protection, Radiological protection, health physics and construction industry.

Cost-effectiveness/value of the work: The project is feasible and low cost to be undertaken by both Universities and research institutes.

Future plans: to continue research in this area, possibly to cover a wide range of technosphere objects and simulate the results to determine the exact contribution of technosphere objects to the background radiation.

Table of Contents

## Introduction

Radiation has accompanied our universe since the Big Bang, the moment our universe was born. Since that time, radiation gradually fills outer space. It follows from this that the composition of the Earth from its very birth includes radioactive materials. It follows from this that the world around us is radioactive, and most of the energy of ionizing radiation is absorbed in human organs and tissues.

Radiation monitoring of the environment is designed to ensure protection of the population from the harmful effects of ionizing radiation on their health. One of the most important criteria for assessing the degree of radiation exposure is the radiation dose. The radiation dose to the public is controlled only by external gamma radiation, which is emitted by natural sources such as space and earth. For urban residents, objects of the technosphere are an additional source of radiation.

In accordance with the Presidential Decree namber 585: «On approval of the basis of the state policy in the field of nuclear and radiation safety of the Russian Federation» for the period up to 2025 one of the main policy objectives in the nuclear and radiation safety is to reduce the harmful effects of radiation factors on the population living in the territories with an increased level of natural background radiation. Therefore, the evaluation of gamma background in the urban environment is an important aspect of the radiological protection of the population.

The sources of radiation can be materials of natural origin that have an increased gamma background and are used as construction and finishing materials for buildings and urban infrastructure, industrial facilities that cause pollution of surrounding areas with materials used in technological processes, as well as features of the terrain (natural and artificial) affecting the amount of radiation background.

The purpose of this work is radiation reconnaissance of such objects and territories in order to determine the influence of the level of gamma radiation on the population of the city of Tomsk. To fulfill the stated goal, the following tasks were identified:

– Review and analysis of literature on this topic.

– A series of measurements using a DRG-01T1 wide-range dosimeter based on the ionization method.

– A series of measurements using the DRBP-03 dosimeter-radiometer.

– A series of measurements using a scintillation detector based on a plastic scintillator BC-408.

– Statistical processing of measurement results.

– Comparison of the experimental results for different detectors and draw conclusions about the effectiveness of their work and generalize the results of the study.

## Chapter 1. Literature review

### 1.1 Analysis of the radiological situation in Vladivostok.

Studies evaluating the impact of external sources of ionizing radiation on the population began 60 years ago. This was due to the assessment of the content of natural radionuclides in building materials. Considering the fact that every year mankind uses more and more natural resources, the assessment of the gamma background began to be dealt with in many large cities.

An analysis of the radiological situation in Vladivostok was presented in [2]. Several factors were taken into account at once due to the geographical location of the city. The sources of radioactive contamination and spread are: atmospheric fallout of radionuclides, illegal import of goods and vehicles contaminated with radionuclides, unauthorized storage of radioactive preparations and the use of building materials containing decay products of uranium and thorium series.

Under the careful supervision are almost all of the above sources, but in the construction of objects that have been widely used construction and facing materials - supports natural radionuclides have been investigated enough. The initial data was the information on radiation monitoring of some facilities, located in the city. (Figure 1.1)

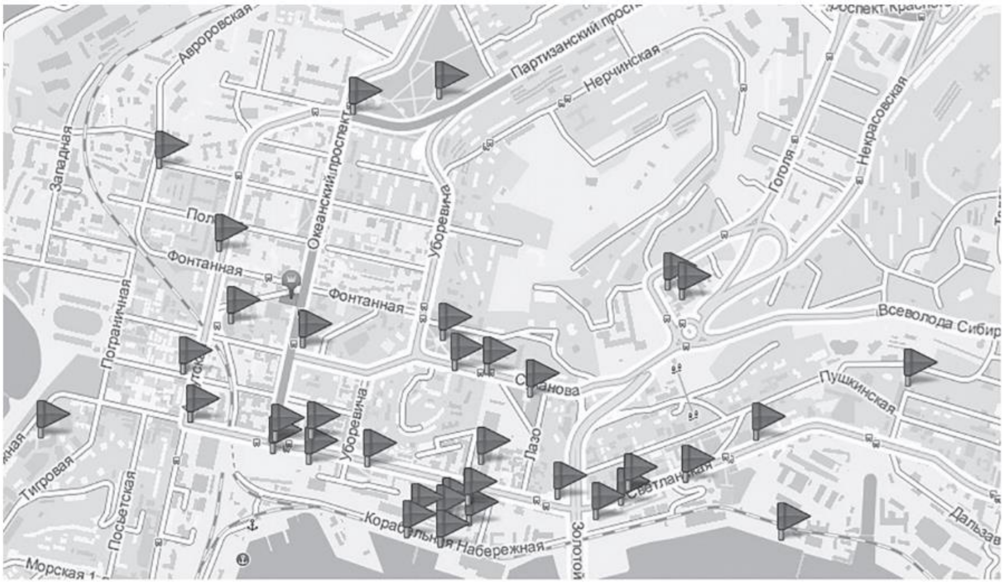


Figure 1.1– Location of radiation sources in Vladivostok.

For measurements, a PM 1203M dosimeter was used that complies with technical instructions 2.6.1.2398 and 2.6.1.2838-11. From which it follows that for measurements of this kind, the required permissible measurement error should be no more than ± 15%. The equivalent dose rate of facing materials of buildings, underground passages and foundations of monuments was measured taking into account the background in the monitoring area in the immediate vicinity of the surface.

During the study, the background radiation from 31 objects in the city of Vladivostok was studied. With a natural background of 0,09 μSv / h, the measured dose rate varied from 0.10 (Alley of sister cities) to 0,40 μSv / h. Three historical monuments made of granite have an abnormally high background (see table 1.1).

Table 1.1 – Sources of technogenic gamma radiation in the city of Vladivostok

| № | location of the anomaly | Effective dose rate, μSv / h |
|---|---|---|
| 1 | Monument to the Fighters for Soviet Power in the Far East | 0,55 |
| 2 | Monument to K. Sukhanov | 0,54 |
| 3 | Monument to A.S. Pushkin | 0,44 |
| 4 | Monument to V. Banevur | 0,55 |
| 5 | GosUniverMag western wall | 0,37 |
| 6 | Gold dump CHP 2 | 0,34 |
| 7 | Coating Custom House | 0,28 |
| 8 | Railway | 0,27 |
| 9 | Shop «Emerald» | 0,22 |
| 10 | Underground passage Svetlanskaya st. - Oceansky prospect | 0,2 |

Also, an increased background radiation was found on the footpath in the park on the street. Admiral Fokin (0,20 μSv / h), at the curbs on Pogranichnaya and Sukhanov streets (0,19 μSv / h and 0,26 μSv / h, respectively), black granite was used for construction or restoration.

Despite the fact that within the territory of Vladivostok, the effective dose rate was within the natural radiation background (2014-2015), the authors note an increase in the number of radiation anomalies, compared with previous years, associated with an increase in the use of construction and facing materials, referred to 2 class of radiation safety.

## 1.2 Analysis of the radiological situation in Arkhangelsk

A similar study was carried out in [3]. The authors investigated the dependence of the radiation background on various factors in the central part of the city of Arkhangelsk. The Laboratory of Ecological Radiology of the Institute of Ecological Problems of the North, Ural Branch of the Russian Academy of Sciences, carried out a complex of studies, consisting of soil studies, measurements of the radioactive background, the volumetric activity of radon in the soil air, and also in each quarter of the city, the content of 137Cs, 40K, 226Ra, 232Th in the upper soil horizon was determined.

For research related to the measurement of the radioactive background, an autonomous mobile complex RS-700 was used, which was installed on a car. The RS-700 Advanced Digital Spectrometer (ADS) System is a High Resolution Gamma Spectrometer (RSX-1 NaI) that can measure both natural and artificial elements in real time. In total, 18 thousand measurements were made 50 m across, at a height of 15 cm from the soil surface. To check the reliability of the results obtained, repeated measurements of the radioactive background were carried out at 100 randomly selected points, which confirmed the initial data with an error of no more than 10%.

The data obtained in the course of the work showed that the radioactive background increases from blocks with wooden buildings to blocks with stone buildings. On average, in blocks with stone buildings, the dose rate is 1.5 times higher than in blocks with wooden buildings. The use of granite as a building material has a significant impact on the spatial distribution of radioactivity in the city. Granite, as an acidic rock, a priori has a high natural level of radioactivity due to the natural radionuclides it contains. Thus, an increase in the dose rate of gamma radiation is recorded in the areas of the Vologda cemetery and on the embankment of the Northern Dvina. In the first case, grave monuments were made from Karelian granite, in the second, granite was used as a facing material for the embankment.

### 1.3 Assessing the impact of ionizing radiation on the population

In scientific work [4], to assess the dose load on the city population, taking into account the recommendations set out in [5], it was proposed to use the following values: the average value of the measured power of the user equivalent dose of gamma radiation (ADR), the average annual effective dose (AEDE), the estimate lifetime radiation-induced cancer risk (ELCR).

The average annual effective dose of external exposure to gamma radiation is calculated based on the measured values of the ambient dose equivalent rate of gamma radiation using the correction factor DCF = 0.7 recommended by UNSCEAR and the occupancy factor OF = 0.2 for external radiation according to formula (1.1). The results are based on the assumption that the average man spends about 4.8 hours outdoors.

$$\mathrm{AEDE\ (mSv/yr) = ADR \cdot T \cdot DCF \cdot OF \cdot 10^{-3}} \tag{1.1}$$

Where ADR – absorbed dose rate , μSv / h;

T – time for one year in hours.

To assess the risks, the likelihood of radiation-induced cancer and genetic effects from low-background ionizing radiation is used. Radiation-induced cancer is associated with the probability of developing the disease throughout life at a given level of radiation [14], which is estimated from the expression:

$$\mathrm{ELCR = AEDE \cdot DL \cdot RF} \tag{1.2}$$

Where AEDE – average annual effective dose of external exposure to gamma radiation;

DL – average life expectancy

RF – risk factor.

The average life expectancy is estimated at 70 years. For stochastic effects, the ICRP uses RF as 0.05 for the population, the world permissible standard is $0.29 \cdot 10^{-3}$ [4]. The calculated average annual effective radiation doses of the population were compared with the recommended safe dose limits and world average values.

### 1.4 Chapter Conclusions

As a result of the study of the literature, articles were studied, including an analysis of the radiological situation in Vladivostok and Arkhangelsk, and a method was identified that allows one to assess the dose load on the city population. The data obtained because of these works allow us to conclude that the use of granite as a building material has the most significant effect on the spatial distribution of radioactivity in the city.

## Chapter 2. Equipment and measurement technique.

Measurements of the ambient dose equivalent rate of gamma radiation were carried out by three different dosimetric devices: DRG - 01T1, DRBP - 03 and a dosimeter based on a scintillation detector. Laser rangefinder ADA Cosmo MINI is used to measure distances to objects and position measurement points.

### 2.1 Wide-range portable exposure dose rate dosimeter DRG - 01T1.

DRG-01T1 is a dosimeter designed to measure the exposure dose rate at workplaces, in adjacent rooms and on the territory of enterprises that use radioactive substances and other sources of ionizing radiation, in the sanitary protection zone and the observation zone. [5]

The dosimeter is a portable, compact, monoblock device. The body of the DRG-01T1 dosimeter is metal cast. The coating of the dosimeters is resistant to detergents. The dosimeter operates from an autonomous power source. The appearance of the dosimeter is shown in Figure 2.1..

Figure 2.1– Dosimeter DRG - 01T1

The operating principle of the dosimeter is based on the registration of electric current pulses arising from the passage of gamma quanta through a gas-discharge counter. The current pulses are converted by the input stage into voltage pulses with the amplitude required for their registration. The pulses are fed through a frequency divider to a four-digit counter. The accumulated information during the measurement cycle on the counter enters the indicator through a decoder that converts the binary-decimal information of the counter into a seven-segment positional code of the indicator. The measurement time is set by an adjustable reference frequency generator. By changing the measurement time, the input information from the detectors is scaled to the absolute value of the output parameter (mR / h, R / h). The generator provides a number of frequencies to control the indicator and monitor the dosimeter's performance.

Table 2.1 - Technical characteristics of the DRG-01T1 dosimeter

| **Parameter** | **Gas-discharge meter parameter value** | |
|---|---|---|
| | **in the "Search" mode** | **in the "Measure" mode** |
| Exposure dose rate measurement range: | 100,0 μR/h ÷99,99 R/h | 10,0 μR/h ÷9,99 μR/h |
| Limit of permissible basic relative measurement error: | ±30% | ±15% |
| Measurement time, no more | 2,5 s | 25 s |
| Energy range of gamma radiation | 0,05÷3,0 MeV | |
| Overall dimensions, | 175×90×55 mm | |
| Weight | 0,6 Kg | |

## 2.2 Dosimeter - radiometer DRBP-03

The dosimeter-radiometer DRBP-03 is designed to measure the equivalent dose and the equivalent dose rate of ionizing photon radiation, as well as the flux density of alpha and beta radiation. The operating principle of the dosimeter is based on converting the energy of ionizing radiation into electrical impulses using gas-discharge Geiger-Muller counters. Structurally, the dosimeter is made in the form of a control panel in a metal case with built-in detectors and a set of remote detection units. The device is completed with an extension bar and a battery charging unit. The appearance of the dosimeter is shown in Figure 2.2..


Figure 2.2 – Dosimeter DRBP-03

The dosimeter DRBP-03 is used for operational dosimetric monitoring of the radiation situation; studies of radiation anomalies; compilation of radiation maps of the area; detecting contamination of clothing, walls, floors, etc. [6].

Table 2.2 - Technical characteristics of the dosimeter DRBP-03

| **Characteristic** | **Value** |
|---|---|
| Energy range of registered ionizing photon radiation, MeV | 0,05–3,0 |
| Energy range of registered α-radiation, MeV | Pu-239 |
| Energy range of registered β –radiation, MeV | 0,15–3,5 |
| Equivalent dose rate measurement range, $\mu Sv / h$ | 0,10–3×$10^6$ |
| Equivalent dose measurement range, mSv | 0,01–104 |
| Measurement range of particle flux density, $s^{-1}cm^{-2}$ | 0,10–700 |
| Basic relative measurement error, % | ±15 |
| Operating conditions of the device | -20°C …+50°C, 95% |
| Full set weight, kg | 3 |

**2.3 Dosimeter based on scintillation detector**

If scintillation counters are used as gamma-radiation receivers, it will be possible to highlight the following advantages. Firstly, scintillation counters of gamma quanta have a high efficiency of registration of gamma radiation from natural radioactive elements. This is due to the fact that the luminescence flashes arising in the phosphor upon absorption of gamma quanta in it can be collected from the entire thickness of the transparent phosphor, therefore, with sufficient dimensions and density of the phosphor in combination with its high transparency for its own emission of luminescence and good optical qualities of the light-collecting system, the average detection efficiency of the scintillation counter of gamma radiation from a radium source can reach 70 – 80 % [7].

Secondly, scintillation counters, being proportional counters, make it possible to estimate the energies of perceived gamma quanta. So, for example, in the emission spectrum of elements of the thorium series there is an intense line with the energy of gamma quanta 2,62 МэВ [8].

Third, scintillation counters with high resolution can be used to build gamma radiometers designed to measure in a wide range of perceived activity [9].

There are several types of scintillation detectors on the basis of which a measuring instrument can be constructed. The main ones are BGO scintillator, CsI scintillator, BC-408 plastic scintillator.

The main advantage of the BGO scintillator is its small radiation length equal to 1.13 cm.This means that with the same volume and volume, the BGO crystal allows one to obtain a much higher photon detection efficiency than NaI (Tl) or CsI (Tl) crystals. The luminescence spectrum of the BGO scintillator is located slightly to the right, in the region of 480 nm, than the sensitivity peak of the bis-alkali photocathode of the photomultiplier tube. The refractive index of the BGO crystal (n = 2.15) is significantly higher than the refractive index of the photomultiplier tube glass. Both of these factors lead to a decrease in the number of photoelectrons. Another technical difficulty is the formation of air bubbles inside the volume of the crystal during its manufacture. Scattering occurs on the bubbles and, accordingly, light is lost. The advantages of the BGO scintillator are its good mechanical properties during processing and non-hygroscopicity [10].

The main advantage of CsI scintillators is that the CsI (Tl) single crystal is almost non-hygroscopic. Small leaks will not lead to the destruction of the single crystal, as is the case with the NaI (Tl) scintillator, however, with prolonged use, the CsI (Tl) crystal must be isolated in a dry environment. The plastic nature of cesium iodide makes it easy to machine. The emission spectrum of the CsI (Tl) scintillator has a maximum at 550 nm and is in poor agreement with the spectral characteristic of a standard bis-alkali photocathode of a photomultiplier tube. For a CsI (Tl) scintillator, a multialkaline photomultiplier photocathode is more suitable. [11].

Plastic scintillators are usually two, three-component mixtures of organic scintillation molecules in a polymer base. Primary fluorescence centers are excited due to the loss of energy by incident particles, and when these excited states decay, light is emitted in the ultraviolet wavelength range. The absorption length of this ultraviolet is very small, because the fluorescence centers are opaque to their own emitted light; therefore, light is extracted by adding a second component to the scintillator, which absorbs the initially emitted light and re-emitting it isotropically at long wavelengths. They possess transparency and the ability to provide high registration efficiency due to their large volume and practically any configuration at a relatively low cost and high temperature stability of the light output, and ease of processing. The main disadvantage of plastic scintillators is their poorer energy resolution compared to inorganic scintillators. The maximum dimensions of plastic scintillators are limited by the attenuation length of their own radiation, up to 5 m. All plastic scintillators are sensitive to X-rays, gamma radiation, fast neutrons and charged particles [12].

One of the main characteristics of scintillation detectors is the decay time. This is the time during which the energy absorbed in the scintillator and excited by the passage of a fast charged particle is converted into light radiation. For inorganic scintillators, the decay time ranges from hundreds of nanoseconds to tens of microseconds. Organic scintillators (plastic and liquid) are illuminated within nanoseconds.

The basis of the dosimeter used in this work is a scintillation detector based on a plastic scintillator BC-408. Pulses from the detector are recorded by a counting system based on the Arduino platform, displayed on the screen and written to the internal memory of the device. The device also includes a stabilized high voltage source with a voltage divider for powering the PMT and a battery.

The appearance of the dosimeter is shown in Figure 2.3.

Figure 2.3 - Dosimeter based on a scintillation detector

## 2.4 Chapter Conclusions

When using a detector of the DRG-01T1 type to measure background values of the dose rate, the value of the relative error can grow up to 60%, which will adversely affect the measurement results.

Summarizing the characteristics of scintillation detectors and considering economic efficiency, reliability and best overall properties, the plastic scintillator BC-408 based on polyvinyltoluene was chosen from their set of scintillation detectors.

To draw a conclusion about the efficiency of measurements of detectors of the DRG-01T1 type and a plastic scintillator BC-408, the third device, the DRBP-03 dosimeter-radiometer, was chosen.

## Chapter 3. Experimental results and their analysis

### 3.1 Planning an experiment.

Radiation reconnaissance of objects and territories in order to determine the influence of the level of gamma radiation on the population of the city of Tomsk was carried out for the following places: granite embankment on the river Ushaika, at the monument "400 years of Tomsk" and at the Karl Marx square. (Figure 3.1) In each zone, several sites were selected, at each site a number of measurement points were selected, which are shown in the corresponding figures by arrows and numbers. The measurements were carried out using a DRG-01T1 wide-range dosimeter, a DRBP-03 dosimeter-radiometer, and a scintillation detector based on a BC-408 plastic scintillator.


Figure 3.1 - Layout of objects: 1 - granite embankment on the river. Ushaika, 2 - monument "400 years of Tomsk" 3 - Karl Marx square, 4 - embankment of the river Tom

### 3.2 Assessment of the radiation situation in the area of the granite embankment of the Ushaika River.

In order to more accurately assess the contribution of technosphere objects to the general gamut of background affecting the population, it was decided to divide this object into 5 parts: Embankment near the bridge, Upper observation deck, Amphitheater, Granite stage, Platform on the other side: H1, H2, H3 , H4, H5, respectively. Their location is shown in Figure 3.2.

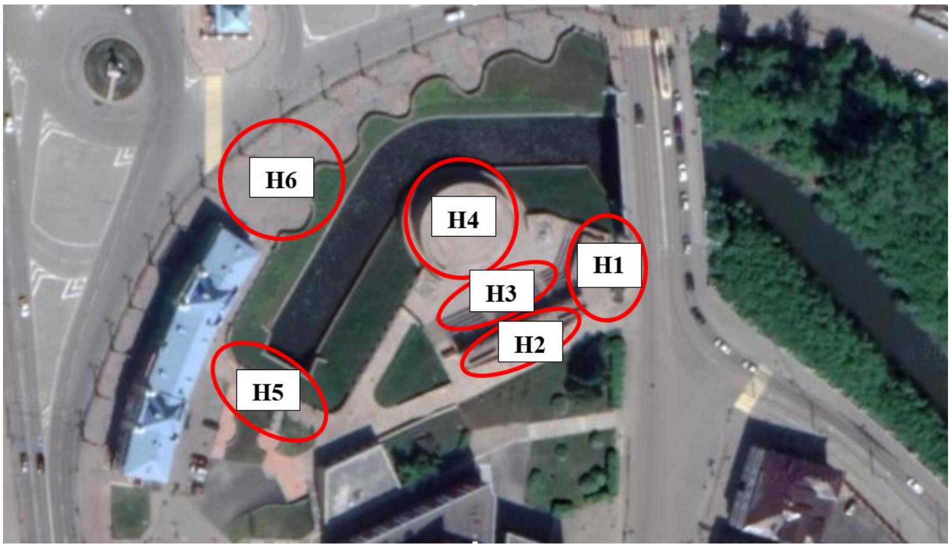


Figure 3.2 - Measurement of background gamma on the embankment of the Ushaika river.

3.2.1 Embankment near the bridge

Figure 3.3 shows the measurement scheme for H1. The measurements were taken in the immediate vicinity of the object (at a distance of 5 cm). At each of the 10 points presented, the three above-mentioned detectors carried out a series of measurements. The number of measurements at each point was 12. The results of measurements are presented in the graph, taking into account the statistical error of the measurement result, Figure 3.4.

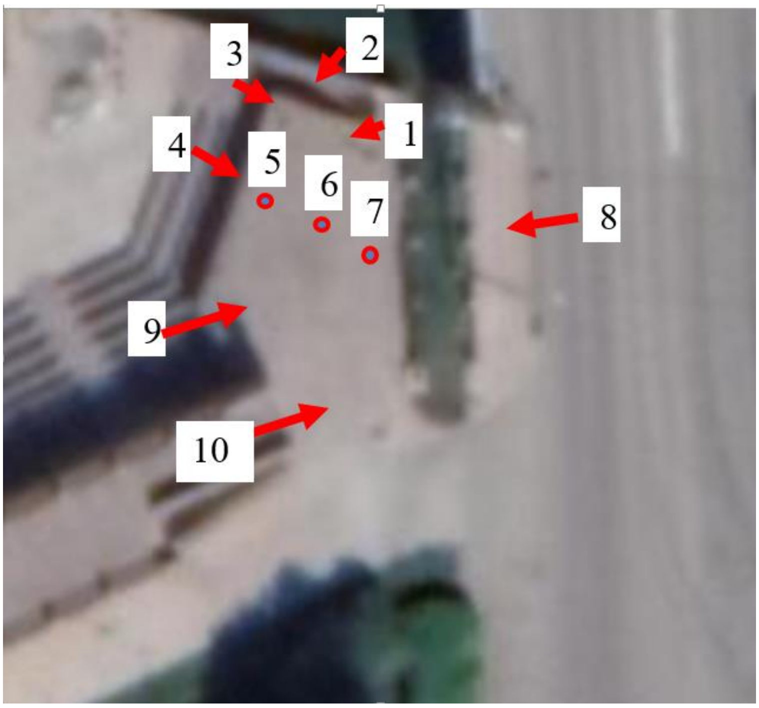


Figure 3.3 - Locations of gamma background measurements and location of points in H1.

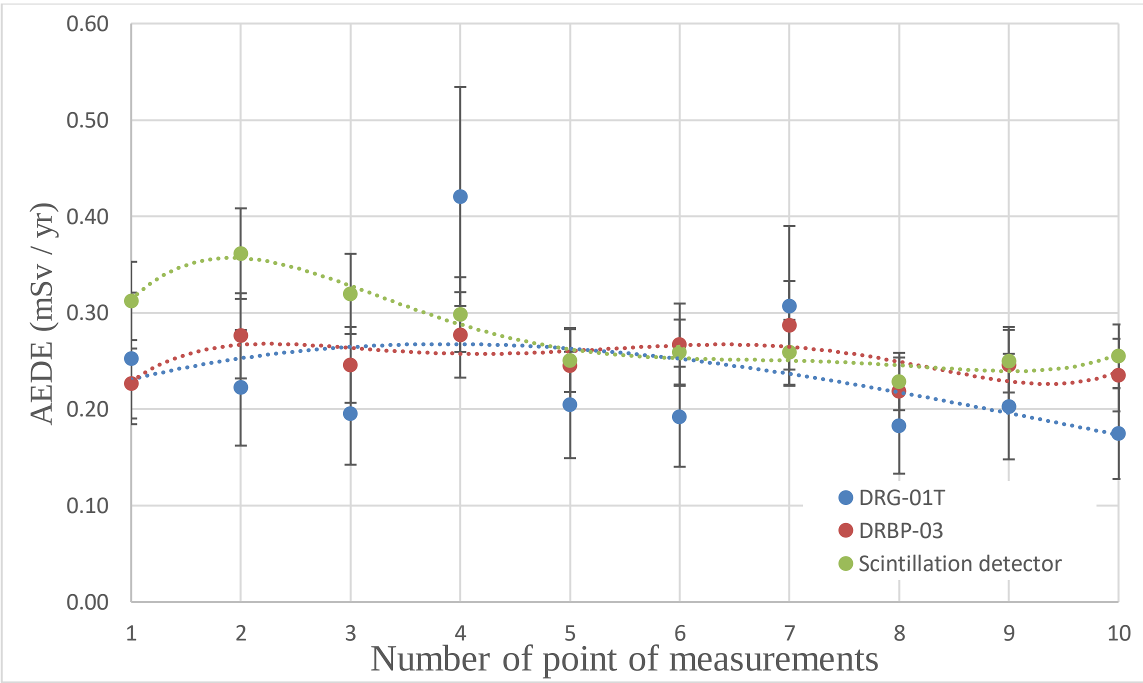


Figure 3.4 - Values of the average annual effective dose of external gamma irradiation in H1.

The control points were chosen in such a way as to localize possible radiation anomalies. Points 1, 2, 3, 4 are selected near the granite facing 8, 9, 10 define the boundaries of the surveyed area, points 5, 6, 7 allow you to estimate the dose rate in the center of the site. Using formulas (1-3), the following values were calculated: absorbed dose, average annual effective dose, and assessment of radiation-induced risk. Considering that all the readings of the detectors are within the statistical error, the average value of the readings of all three detectors can be considered reliable..

Table 3.1 - Calculated average doses for H1

| № point | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| ADR, μSv / h | 0,22 | 0,23 | 0,21 | 0,27 | 0,19 | 0,20 | 0,23 | 0,17 | 0,19 | 0,18 |
| ELCR*$10^{-3}$ | 0,92 | 1,00 | 0,89 | 1,16 | 0,82 | 0,84 | 1,00 | 0,73 | 0,81 | 0,78 |

From Table 3.1 we can conclude the following: the values of the average absorbed dose in the H1 region vary from 0.17 μSv / h to 0.27 μSv / h. Radiation-induced cancer risk values range from 0,73*$10^{-3}$ to 1,16*$10^{-3}$ with recommended values equal $0{,}29 \cdot 10^{-3}$.

Figure 3.5 shows a comparison of the average value of the measured ambient dose equivalent rate of gamma radiation with the background and maximum allowable value.

The background value of the power of external gamma radiation hereinafter was taken from the site of the automated system for monitoring the radiation situation in the Tomsk region, one of the control points of which is located at ul. Gagarin 3, in the immediate vicinity of the measurement site.

The maximum permissible value is specified in the basic sanitary rules for ensuring radiation safety [25], where it is established that the level should not exceed 0.3 μSv / h or 30 μR / h.

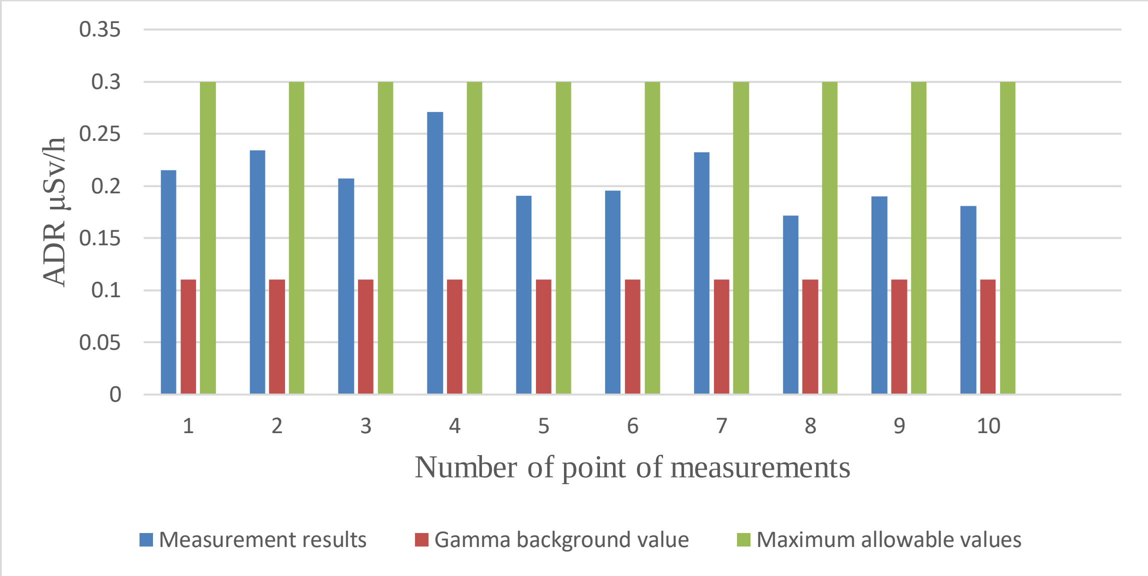


Figure 3.5 - Comparison of the measurement results in H1 with the background and maximum allowable value.

As can be concluded from the data obtained, the entire H1 site has an increased background radiation almost 2 times higher than the background values. The increase in the background at points 1, 2, 3, 4 can be explained by the use of granite blocks in the construction of this structure, and with distance from them at points 5, 6, 8, 9, 10, the dose rate decreases.

3.2.2 Upper observation deck

Figure 3.6 shows the measurement scheme for H2. Control points 1, 2, 3, 4 allow you to obtain data on the average dose received by the population when visiting the upper observation deck 5, 7, 8, 9 allow you to determine the dose rate at the granite facing of this building, point 10 is selected at the granite staircase.

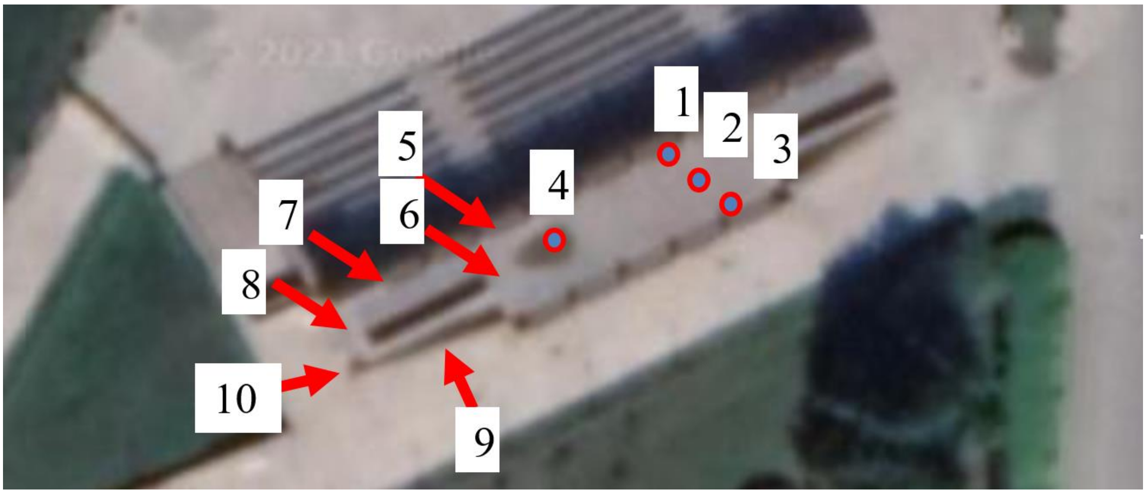


Figure 3.6 – Locations of gamma background measurements and location of points in H2.

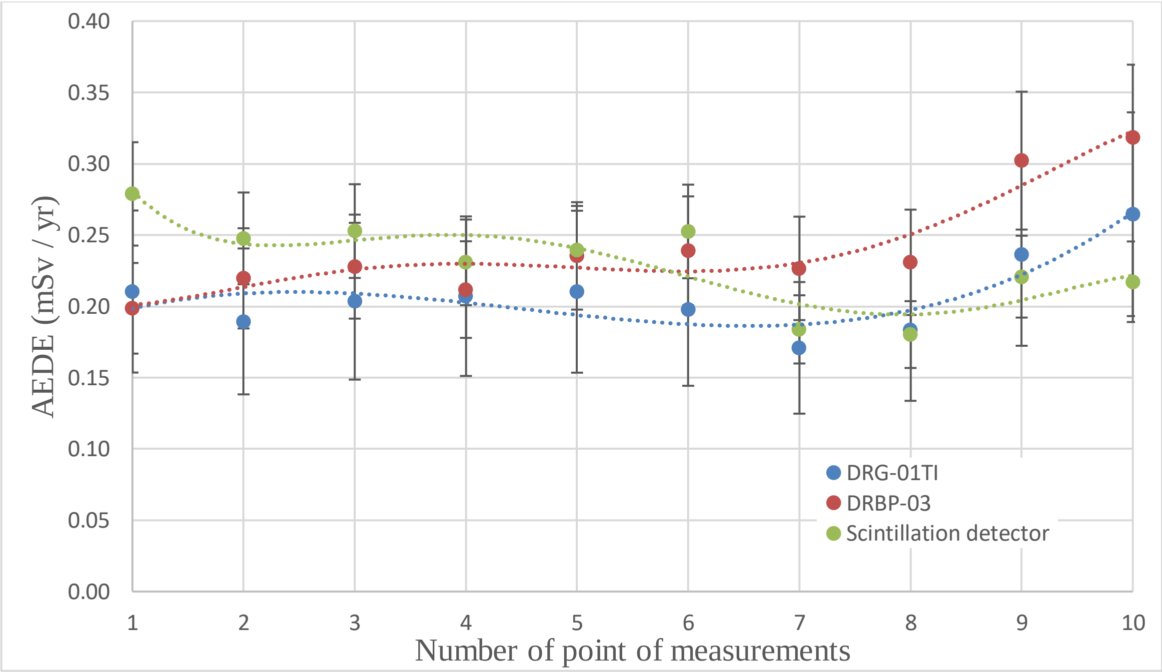


Figure 3.7 – Average annual effective dose of external gamma irradiation in H2.

Table 3.2 below shows the measured ambient dose rate and the calculated radiation-induced cancer risk.

Table 3.2 - Calculated average doses for H2

| № point | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| ADR, μSv / h | 0,19 | 0,18 | 0,19 | 0,18 | 0,19 | 0,19 | 0,16 | 0,16 | 0,21 | 0,22 |
| ELCR*$10^{-3}$ | 0,74 | 0,66 | 0,71 | 0,72 | 0,74 | 0,69 | 0,60 | 0,64 | 0,83 | 0,93 |

From Table 3.2 we can conclude the following: the values of the average absorbed dose in the H2 region vary from 0.16 μSv / h to 0.22 μSv / h. Radiation-induced cancer risk values range from $0,60*10^{-3}$ to $0,93*10^{-3}$ at recommended values $0,29 \cdot 10^{-3}$.

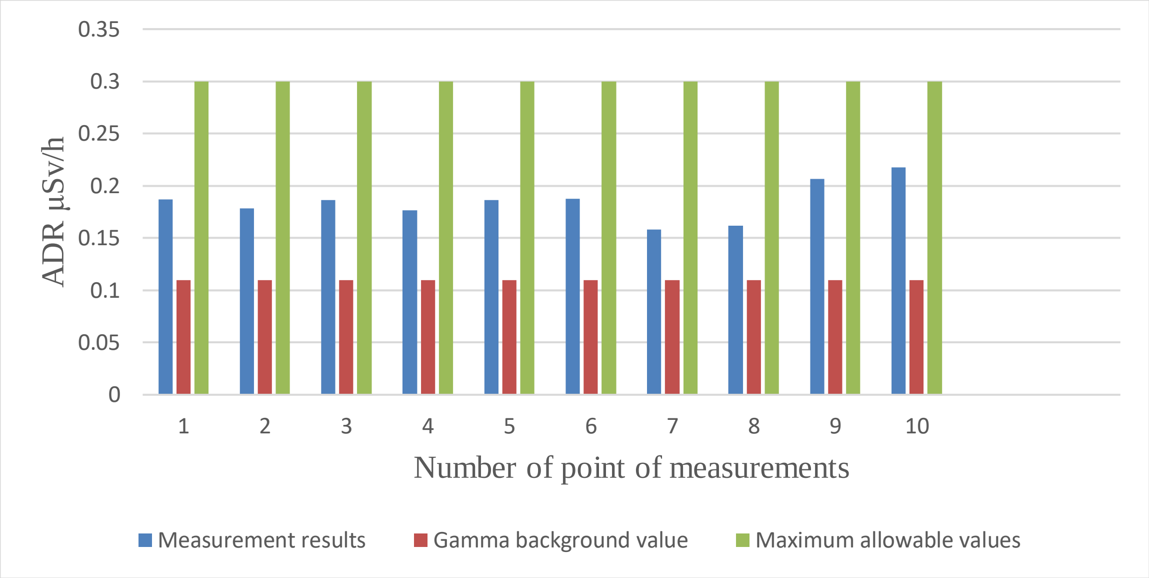


Figure 3.8 Comparison of measurement results in H2 with background and maximum allowable value.

An excess of the dose rate over the background values is observed throughout the study site, and the most significant increase in ADR is observed at points 8 and 10, since these points are located on the stairs made of granite blocks.

3.2.3 Amphitheater

Figure 3.9 shows the measurement diagram for the H3.

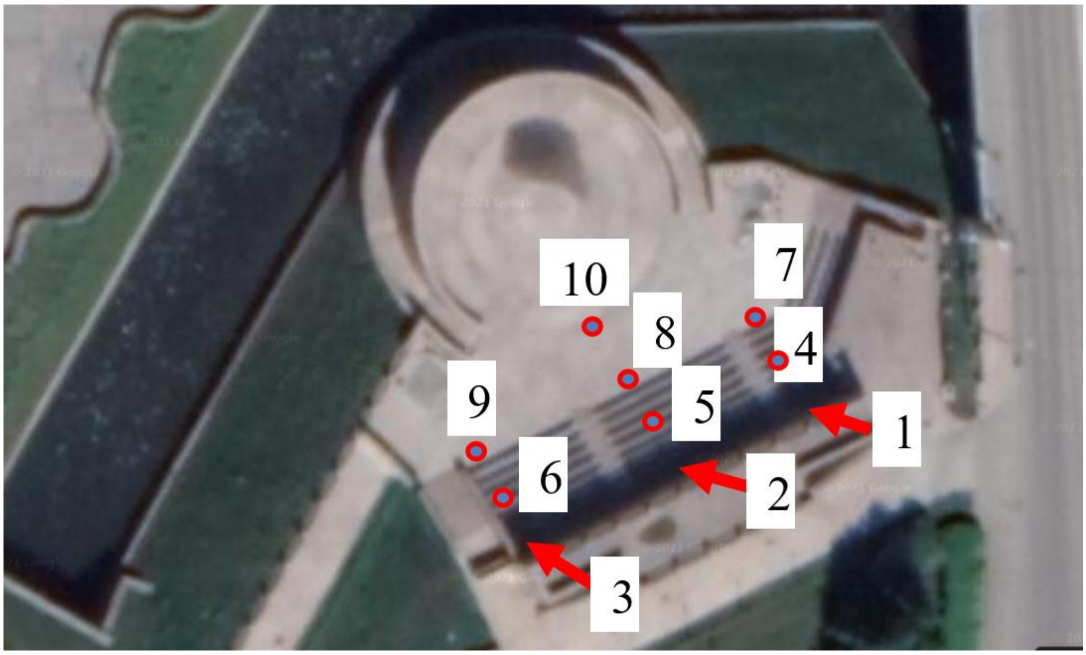


Figure 3.9 – Locations of gamma background measurements and location of points in H3.

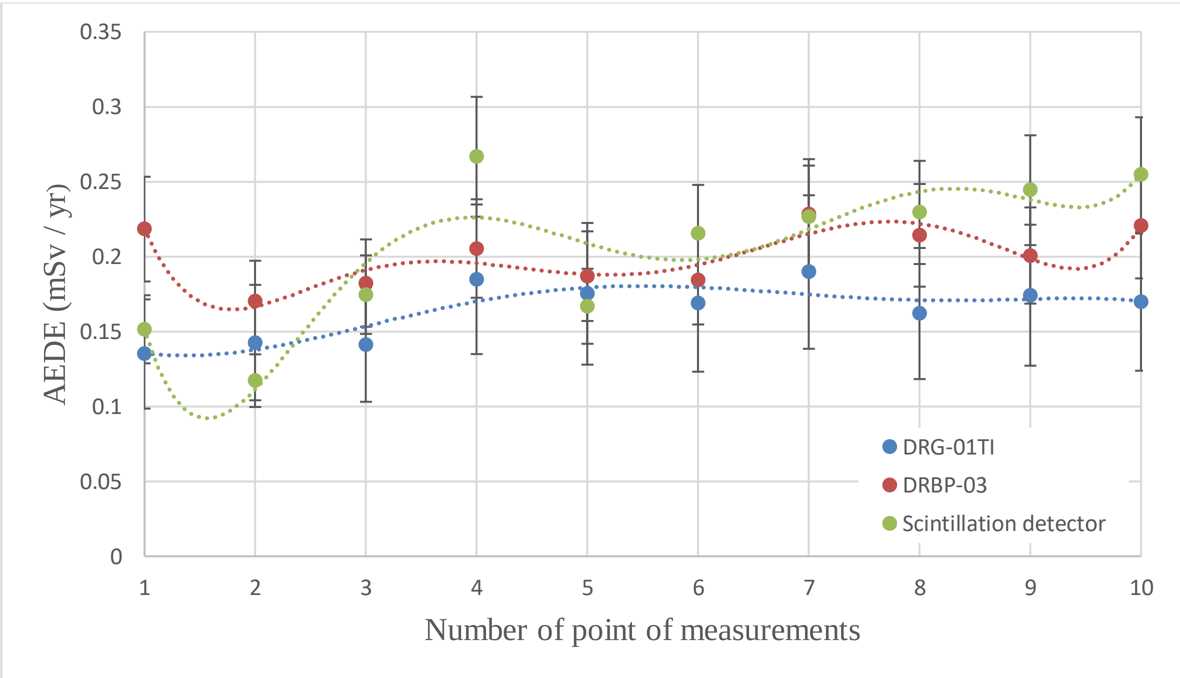


Figure 3.10 – Average annual effective dose of external gamma irradiation in H3.

The points of measurements were chosen on the assumption that the points located near the granite facing (1, 4, 7, 3, 6, 9) will have an increased background, points (2, 5, 8, 10) were taken as the most likely places of rest for the townspeople. The table below shows the measured ambient dose rate and the calculated radiation-induced cancer risk.

Table 3.3 - Calculated average doses for H3

| № point | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| ADR, μSv/h | 0,17 | 0,14 | 0,17 | 0,22 | 0,18 | 0,19 | 0,21 | 0,20 | 0,21 | 0,22 |
| ELCR*$10^{-3}$ | 0,58 | 0,61 | 0,61 | 0,79 | 0,75 | 0,72 | 0,81 | 0,70 | 0,75 | 0,73 |

From Table 3.3 we can conclude the following: the values of the average absorbed dose in the H3 region vary from 0.14 μSv / h to 0.22 μSv / h. Radiation-induced cancer risk values range from 0,58*$10^{-3}$ to 0,81*$10^{-3}$ with recommended values equal $0{,}29 \cdot 10^{-3}$.

Figure 3.11 shows a comparison of the average value of the measured ambient dose equivalent rate of gamma radiation with the background and maximum allowable value.

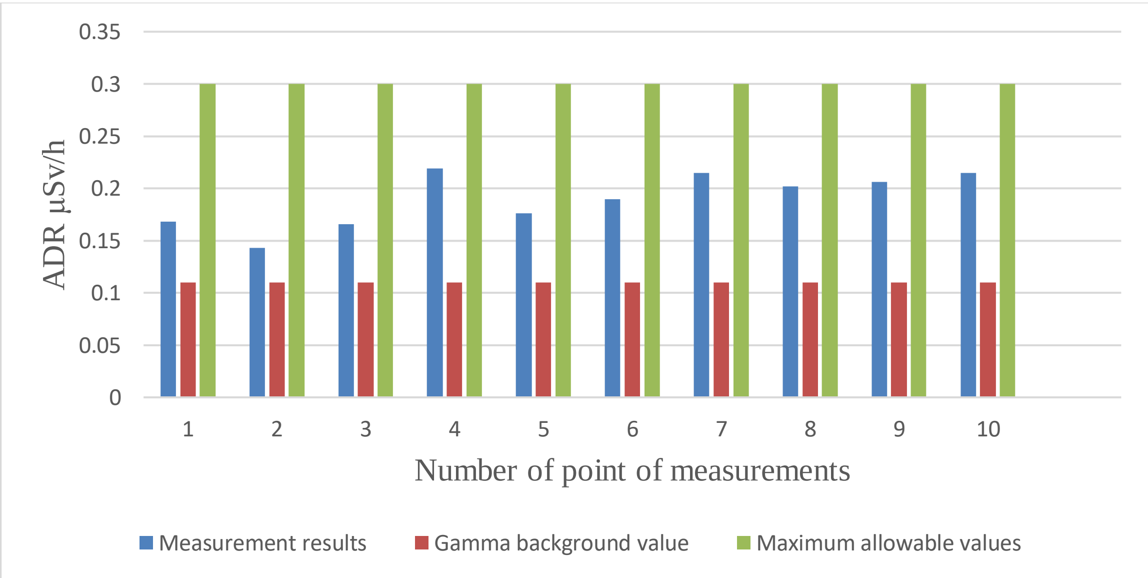


Figure 3.11 – Comparison of the measurement results in H3 with the background and maximum allowable value.

Despite the fact that the average annual effective radiation dose does not exceed the established norms, the dose rate at points 4, 7, 8, 9, 10 significantly exceeds the background values. And the risk of developing radiation-induced cancer is more than twice the recommended rate.

3.2.4. Granite stage

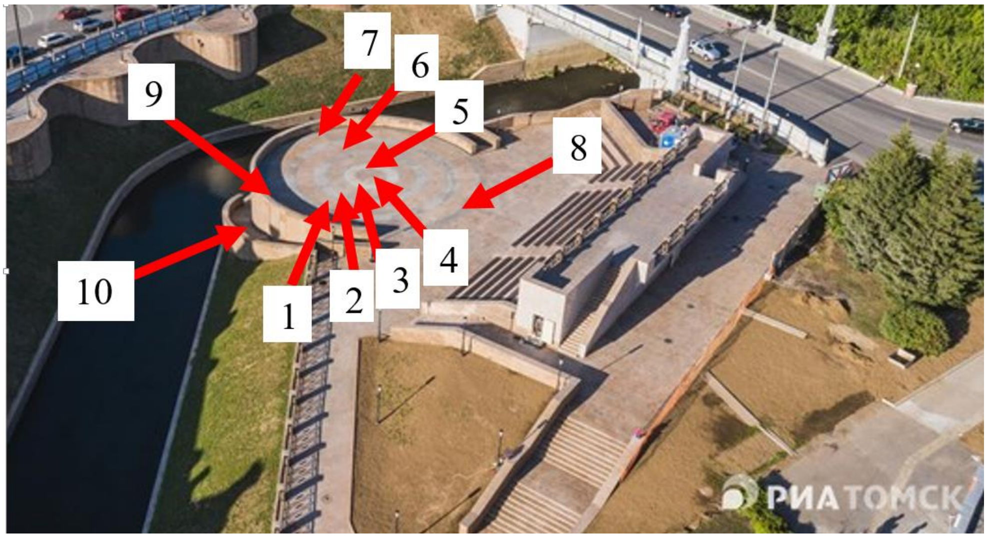


Figure 3.12 – Locations of gamma background measurements and location of points in H4.

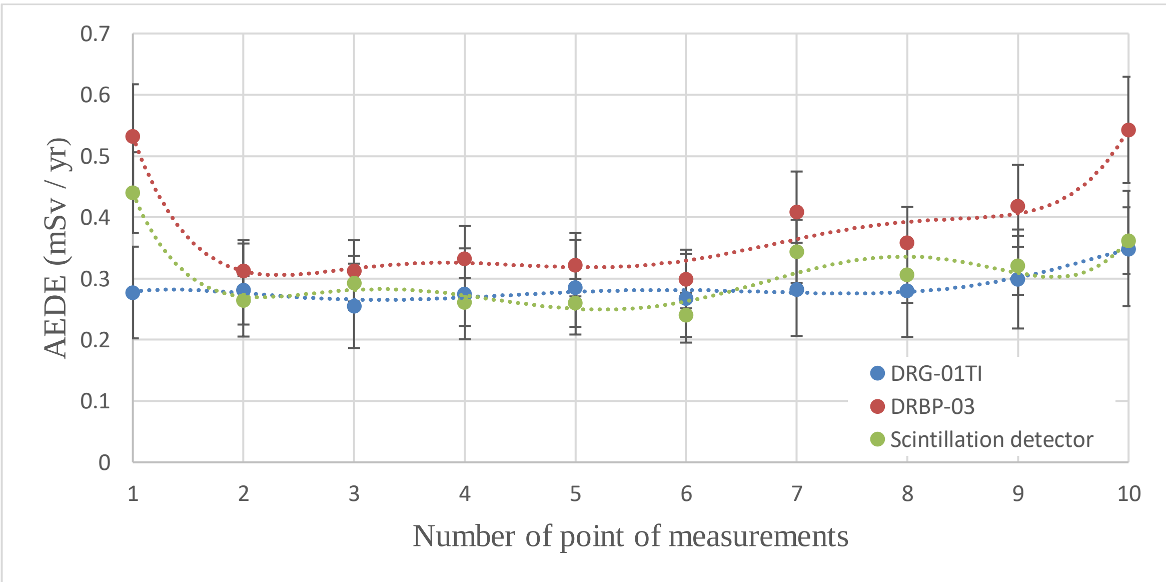


Figure 3.13 – Average annual effective dose of external gamma irradiation in H4.

The measurement points were chosen to compile the most accurate radiological map of this place of rest of the townspeople. The table below shows the measured ambient dose rate and the calculated radiation-induced cancer risk.

Table 3.4 - Calculated average doses for H4

| № point | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| ADR, μSv/h | 0,25 | 0,17 | 0,17 | 0,17 | 0,17 | 0,16 | 0,21 | 0,19 | 0,21 | 0,25 |
| ELCR*$10^{-3}$ | 0,88 | 0,60 | 0,61 | 0,61 | 0,60 | 0,57 | 0,73 | 0,67 | 0,72 | 0,88 |

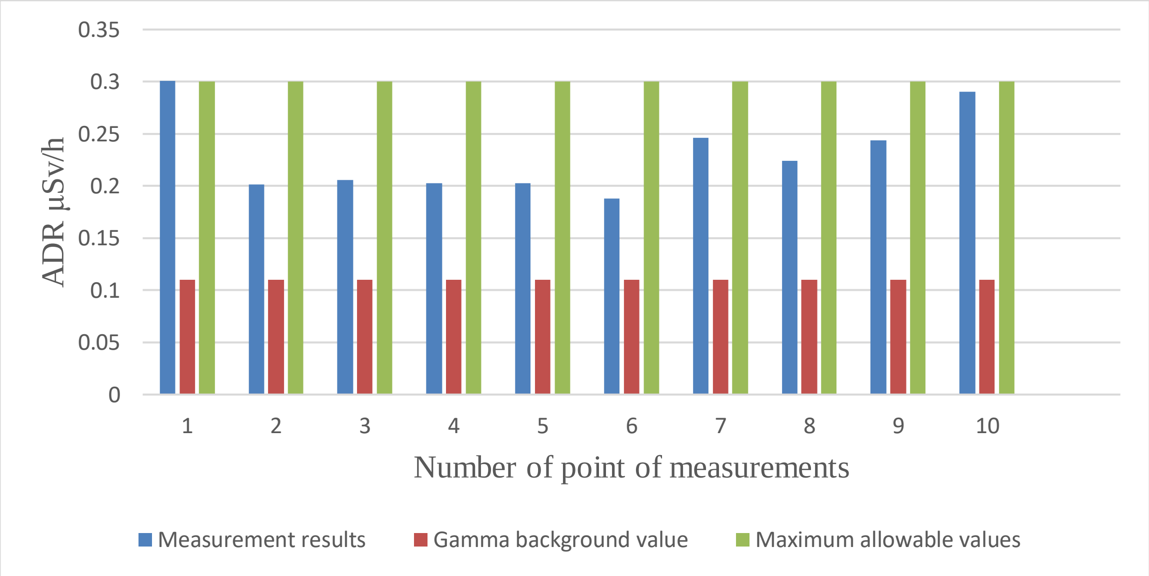


Figure 3.14 – Comparison of the measurement results in H4 with the background and maximum allowable value.

Analyzing the data from Table 3.4 and Figure 3.14, we can draw the following conclusions: based on the assumptions that the scene is entirely composed of granite, the dose rate values at points 3, 4, 5, 6 should be the largest, but in practice we observe that the excess relative to the average the values are observed at points 1,9,10 near the staircase, this allows us to conclude that during the construction of this staircase, granite with an increased content of radionuclides was used.

### 3.2.5 The site on the other side

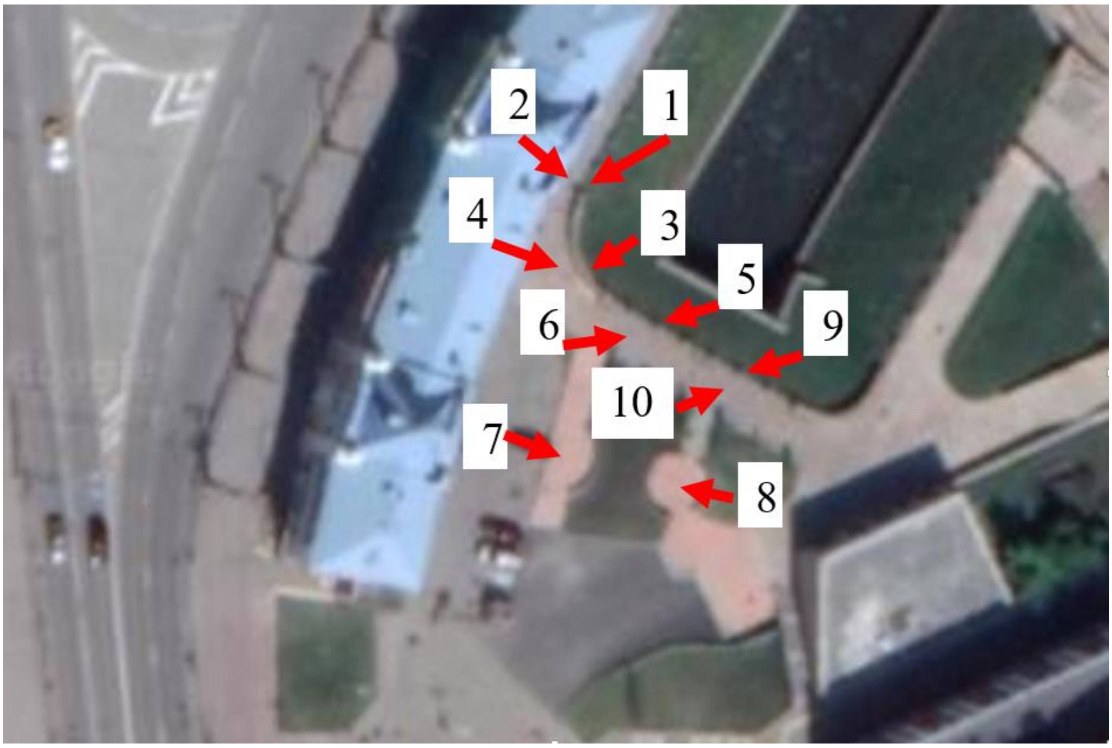


Figure 3.15 – Locations of gamma background measurements and location of points in H5.

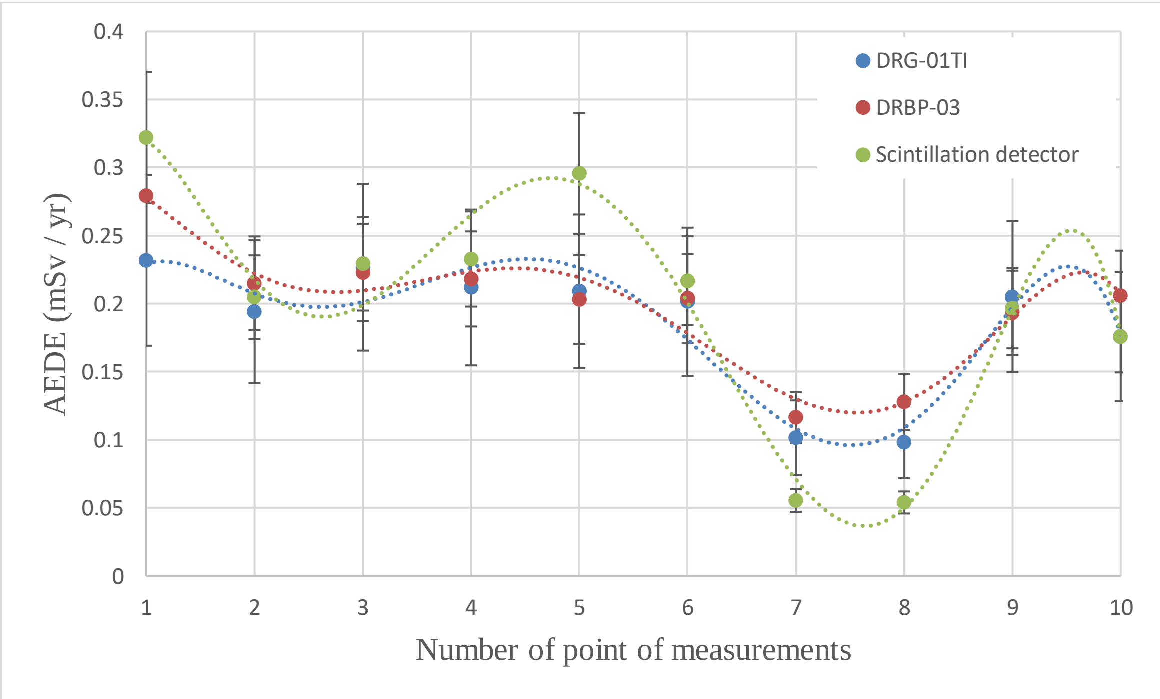


Figure 3.16 – Average annual effective dose of external gamma irradiation in H5.

Point 1, 3 and 5 were at a distance of 5 cm from the stone wall, point 9 was at the stone columns that served as the foundation for the iron fence. Point 2, 4, 6 and 10 were at a distance of 1 m from 1, 3.5, 9, respectively. Point 7 and 8 were located far from all objects of the technosphere.

Таблица 3.5 – Calculated average doses for H5

| № point | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| ADR, μSv/h | 0,28 | 0,20 | 0,23 | 0,22 | 0,24 | 0,21 | 0,09 | 0,09 | 0,20 | 0,19 |
| ELCR*$10^{-3}$ | 0,97 | 0,72 | 0,79 | 0,77 | 0,83 | 0,73 | 0,32 | 0,33 | 0,69 | 0,65 |

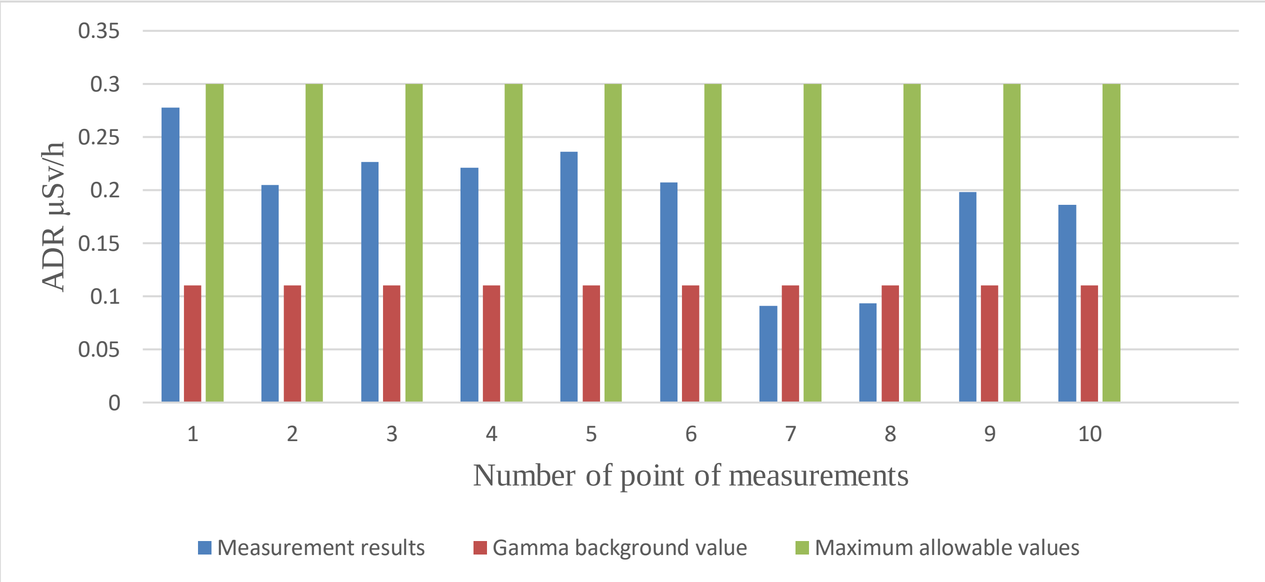


Figure 3.17 Comparison of measurement results in H5 with background and maximum allowable value.

Taking into account the data obtained as a result of the experiment, it can be concluded that the dose rate at points 1, 2 and 5, 6 significantly decreases with distance from the objects of the technosphere, for points 3 and 4 and 9, 10, a similar dependence is also observed, but a decrease in the dose not so significant. The values at points 7 and 8 are compared with theoretical expectations and these values are closest to the background values.

3.2.6 Pedestrian area at the bus stop Lenin Square.

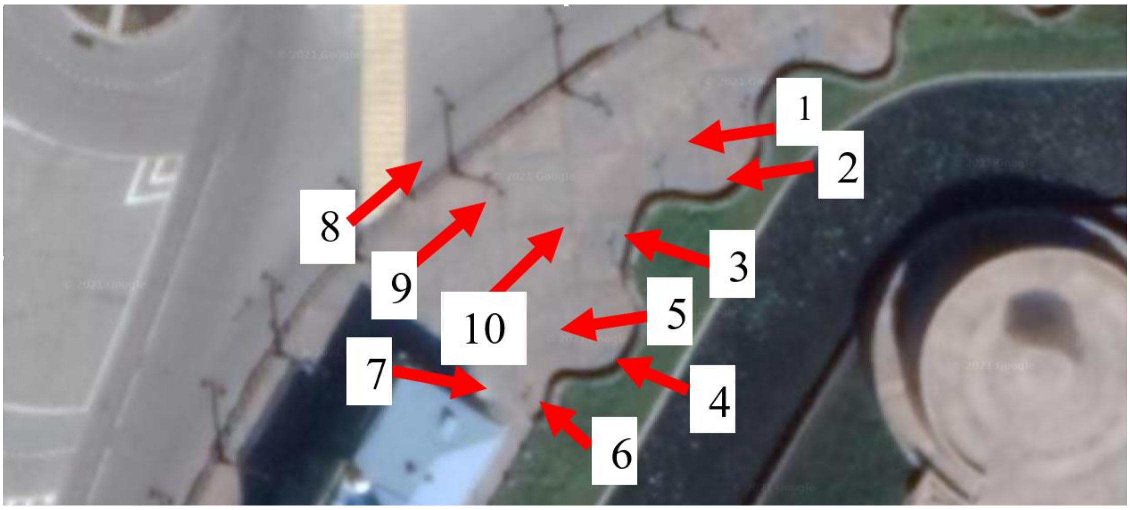


Figure 3.18 – Locations of gamma background measurements and location of points in H6.

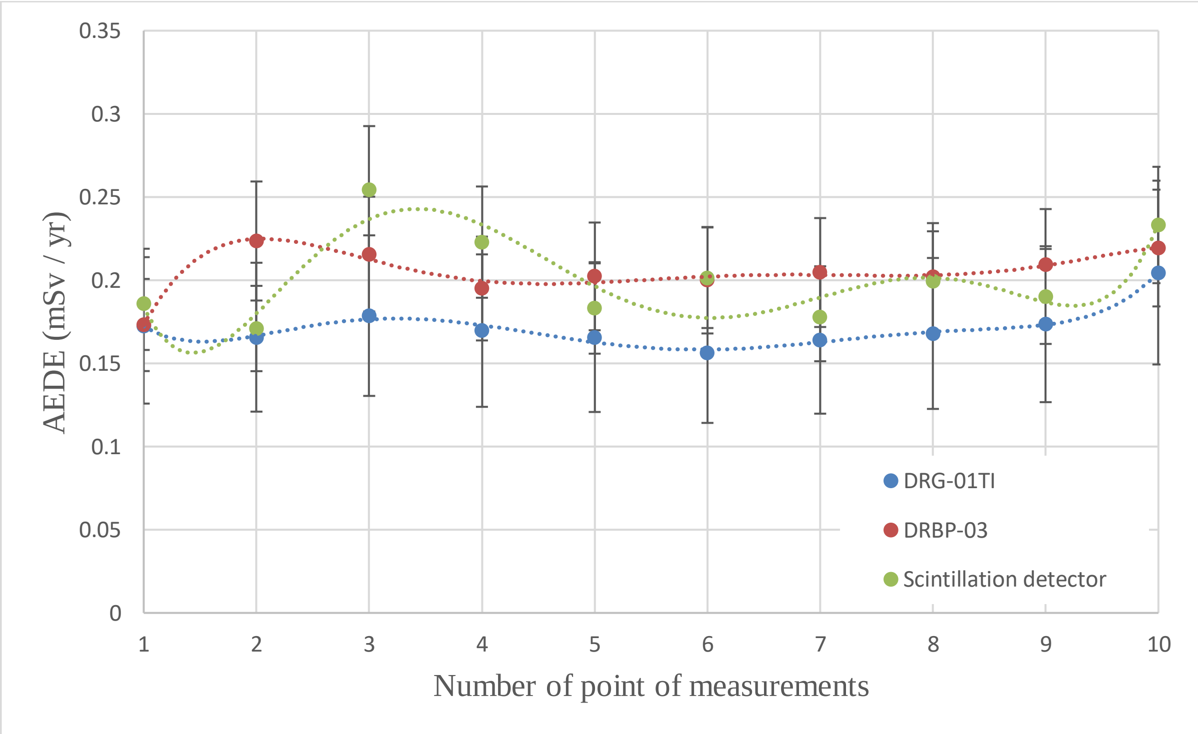


Figure 3.19 – Average annual effective dose of external gamma irradiation in H6.

Point 2, 3, 4, 6 were located at a distance of 5 cm from the sidewalk curbs. Point 1, 5, 7, 9, 10 are at a distance of 1 m from the above. Point 8 is at the base of the lamppost.

Table 3.6 - Calculated average doses for H6

| № point | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| ADR, μSv/h | 0,17 | 0,17 | 0,18 | 0,17 | 0,17 | 0,16 | 0,16 | 0,17 | 0,17 | 0,20 |
| ELCR*$10^{-3}$ | 0,74 | 0,71 | 0,77 | 0,73 | 0,71 | 0,67 | 0,70 | 0,72 | 0,75 | 0,88 |

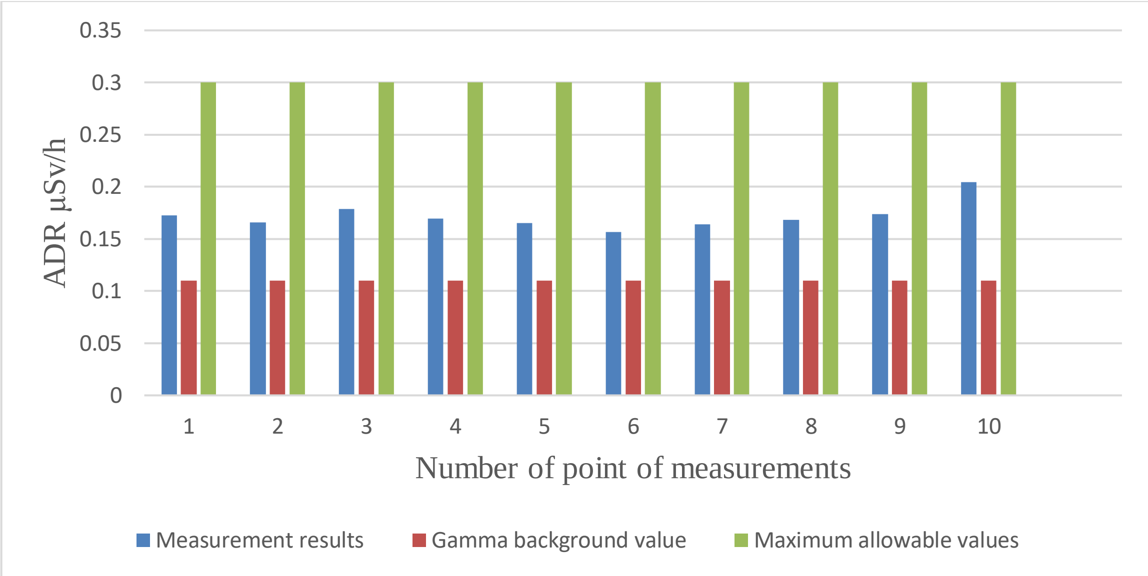


Figure 3.20 – Comparison of the measurement results in H6 with the background and maximum allowable value.

From the data given above, it can be noted that the average dose rate is within the entire measured area within 0.17 μSv / h, the deviation from this value is observed only at point 10, which does not quite coincide with theoretical assumptions, since the point is located away from point 3 with a potentially high ADR value. This can be associated with the materials used in the construction and it can be concluded that the source of the increased gamma background is under the paving slabs. The risk of developing cancer is also at the same level or 2.7 times higher than the recommended one.

**3.3.** Assessment of the radiation situation near the monument "400 years of Tomsk"»

To estimate the required values near the monument "400 years of Tomsk" (P1), the measurement scheme was chosen as shown in Figure 3.21.

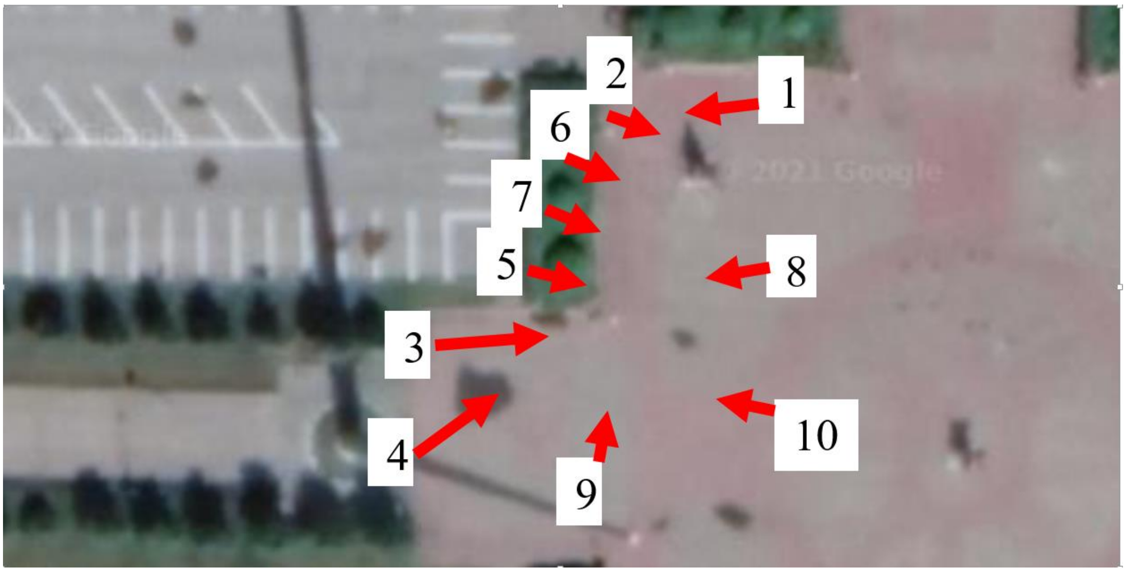


Figure 3.21 – Locations of gamma background measurements and location of points in P1.

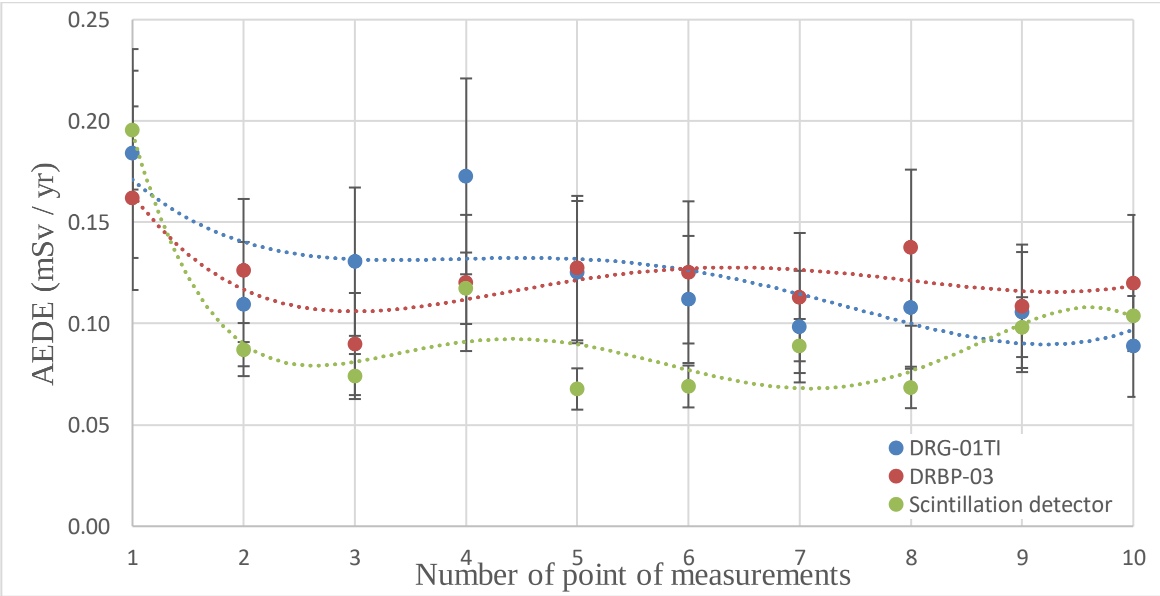


Figure 3.22 – Average annual effective dose of external gamma irradiation in P1.

Point 1 and 4 were located directly at the surface of the columns, point 2, 3 at a distance of 1 m from 1, 4. Point 5, 6 were located at a distance of 1 m from 2, 3. 7 between 5 and 6. 8, 9, 10 are taken on distance of 4 meters from the objects of the technosphere and determined the boundaries of the investigated area.

Table 3.7 – Calculated average doses for P1

| № point | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| ADR, µSv/h | 0,14 | 0,08 | 0,08 | 0,11 | 0,08 | 0,08 | 0,08 | 0,08 | 0,08 | 0,08 |
| ELCR*$10^{-3}$ | 0,48 | 0,29 | 0,27 | 0,37 | 0,29 | 0,28 | 0,27 | 0,29 | 0,28 | 0,28 |

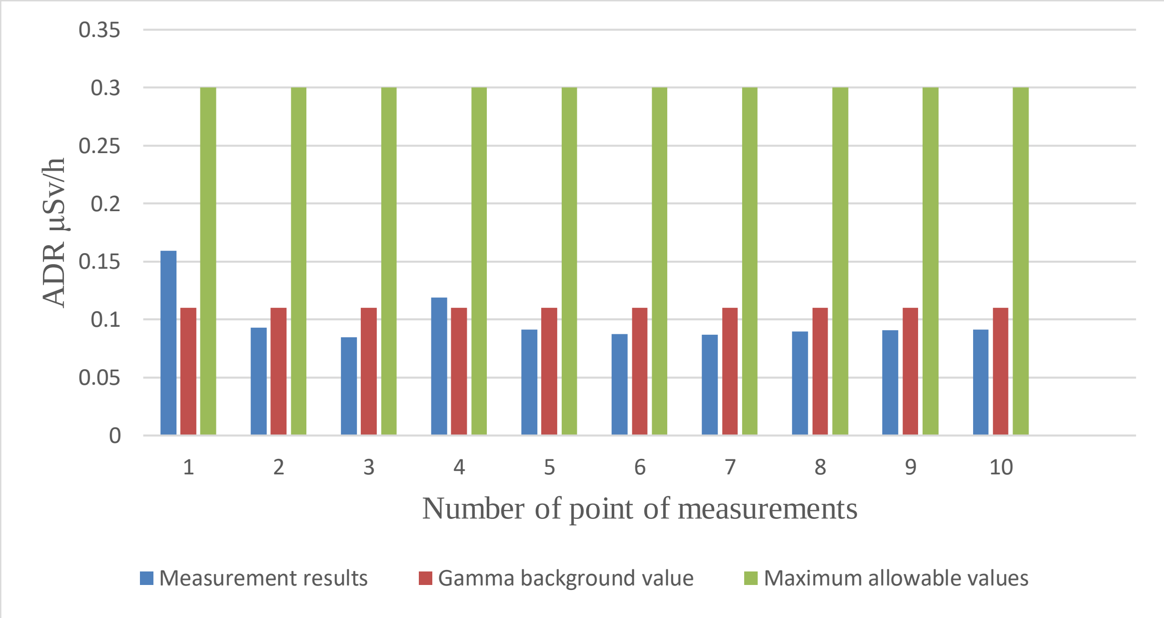


Figure 3.23 – Comparison of measurement results in P1 with background and maximum allowable value.

It can be seen from Table 3.7 and Figure 3.23 that the ADR values exceed the background values only at points 1 and 4 near the monuments. The situation is similar for the ELCR, the radiation-induced cancer risk exceeds the recommended values only at these points. From the data obtained, it follows that at a distance of 1 m, the risk of developing cancer is reduced by 1.7 times.

### 3.4 Assessment of the radiation situation on the territory of the Karl Marx square

To estimate the required values in the Karl Marx square (C1), the measurement scheme was chosen as shown in Figure 3.24.

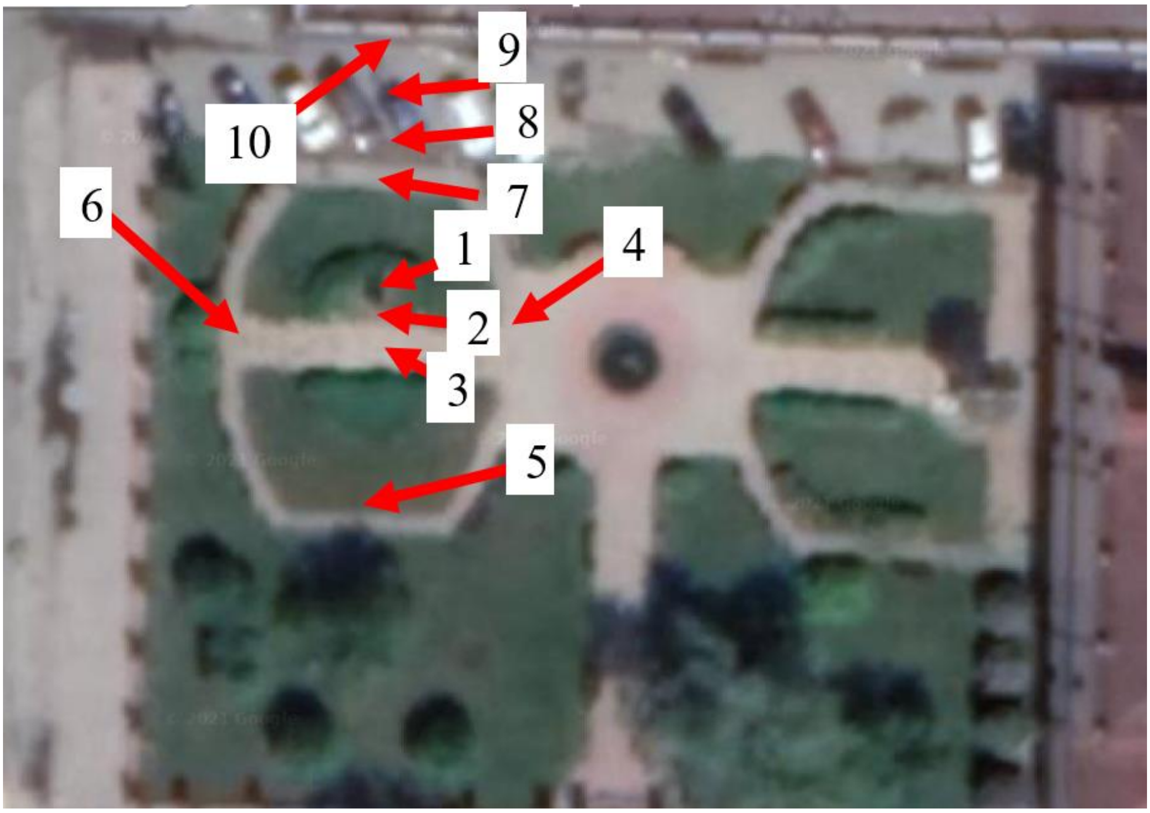


Figure 3.24 – Locations of gamma background measurements and location of points in C1.

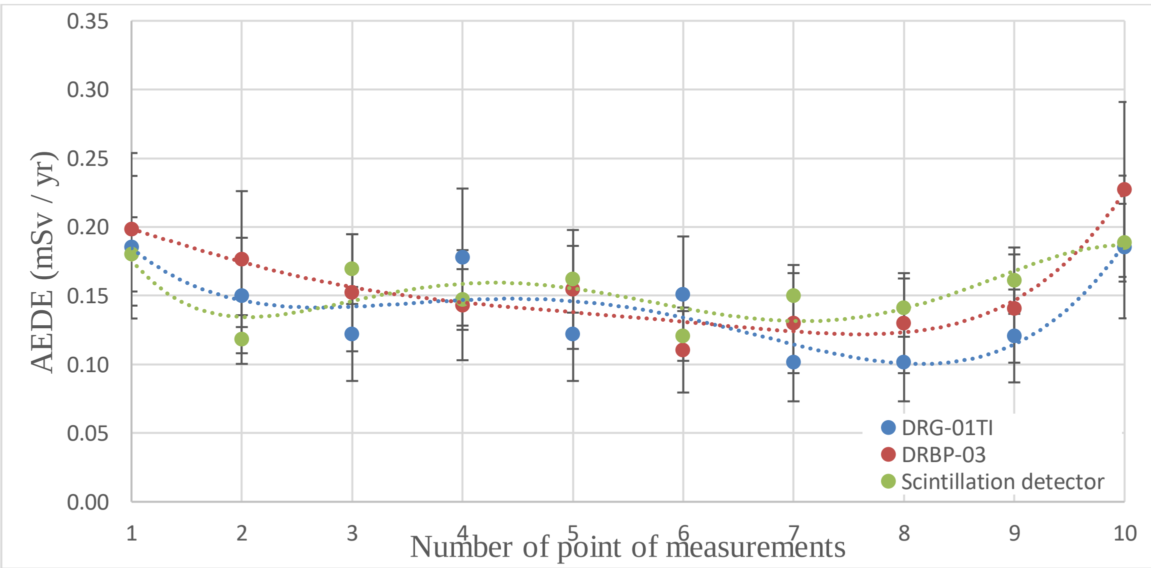


Figure 3.25 – Average annual effective dose of external gamma irradiation in C1.

Point 1, 2, 3 were chosen at a distance of 5cm, 1m and 2m from the stone column. 4, 5, 6, 7 define the boundaries of the study area, 10, 9, 8 were chosen at a distance of 5cm, 1m and 2m from the granite facing of the building.

Table 3.8 - Calculated average doses for C1

| № point | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| ADR, µSv/h | 0,15 | 0,12 | 0,10 | 0,11 | 0,10 | 0,09 | 0,08 | 0,08 | 0,09 | 0,16 |
| ELCR*$10^{-3}$ | 0,51 | 0,34 | 0,24 | 0,21 | 0,23 | 0,17 | 0,21 | 0,20 | 0,23 | 0,51 |

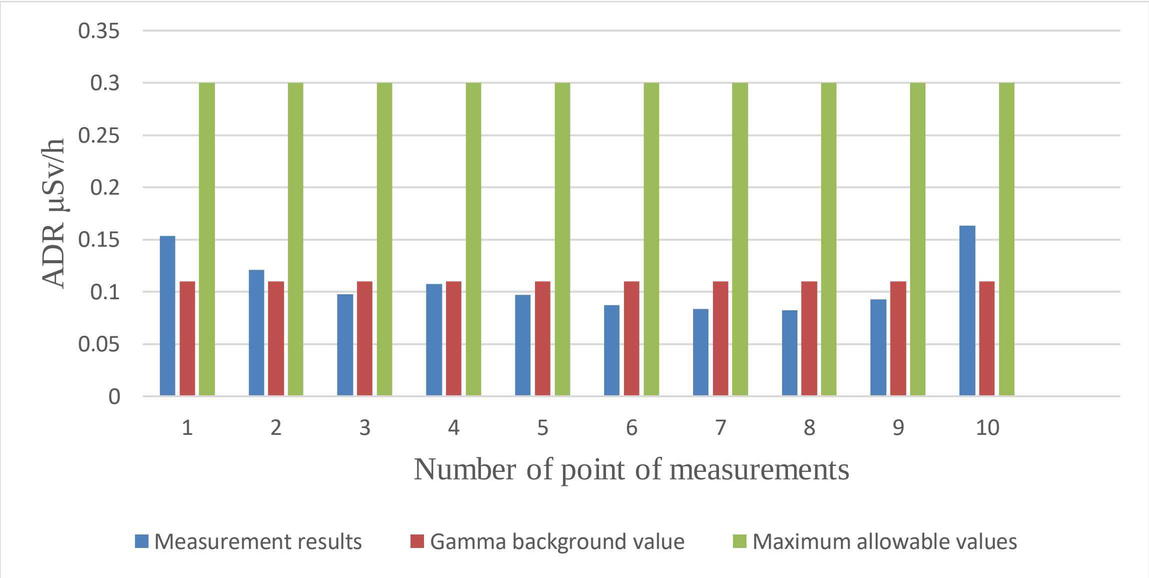


Figure 3.26 – Comparison of measurement results in C1 with background and maximum allowable value.

For this measurement site, a pattern similar to the previous results is observed: when the detector is removed from the technosphere object at a distance of 2 m, the dose rate decreases 5 times (points 1, 2, 3 and 8, 9, 10). Values away from such objects are within normal limits.

### 3.5 Assessment of the radiation situation on the embankment of the Tom River.

To assess the required values on the embankment of the Tom river further B1, the measurement scheme was chosen as shown in Figure 3.27

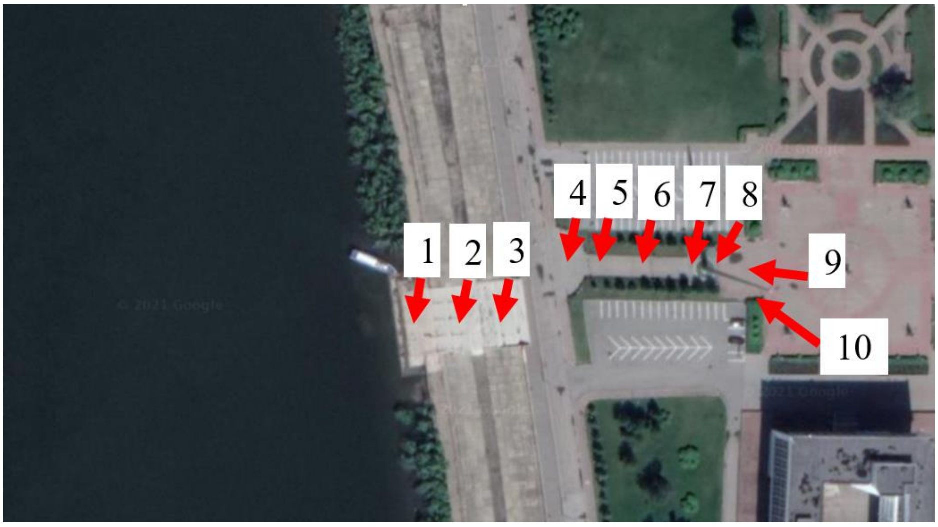


Figure 3.27 – Locations of gamma background measurements and location of points in B1.

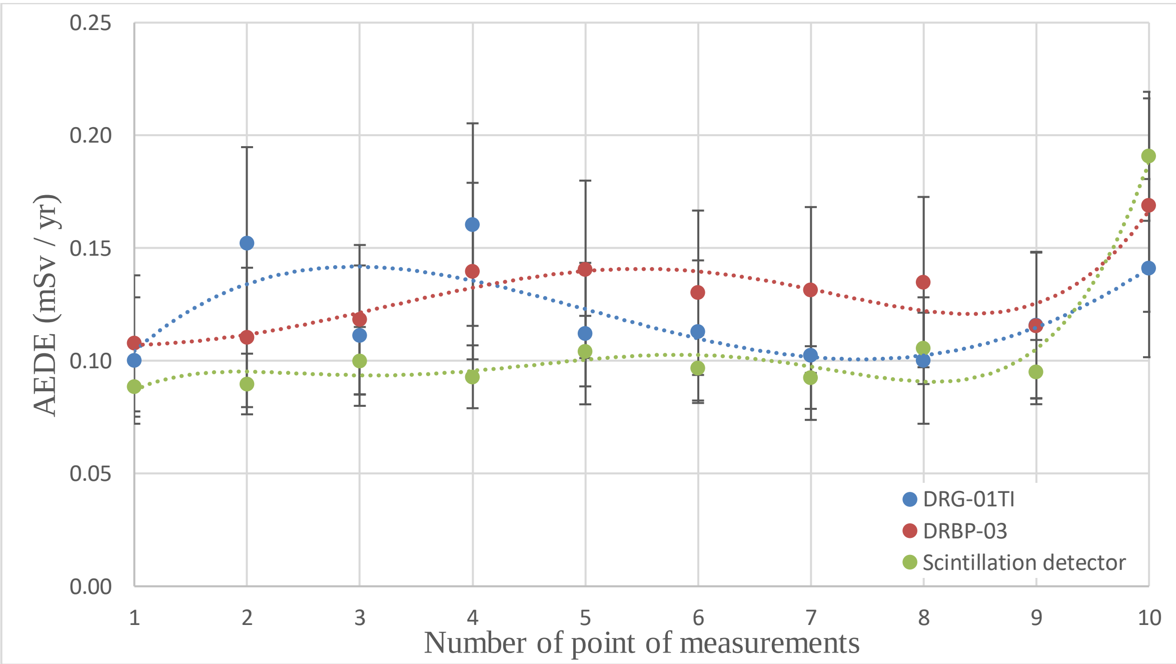


Figure 3.28 – Average annual effective dose of external gamma irradiation in B1.

Points are spaced 3 m apart. Point 1-7 allow estimating the dose rates that people receive when walking along this route, 7-8 are selected at the base of the flagpole, 9 on paving slabs and 10 at a stone wall.

Table 3.9 - Calculated average doses for B1

| № point | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| ADR, µSv/h | 0,10 | 0,12 | 0,11 | 0,13 | 0,12 | 0,11 | 0,11 | 0,11 | 0,11 | 0,17 |
| ELCR*$10^{-3}$ | 0,35 | 0,41 | 0,38 | 0,46 | 0,42 | 0,40 | 0,38 | 0,40 | 0,38 | 0,58 |

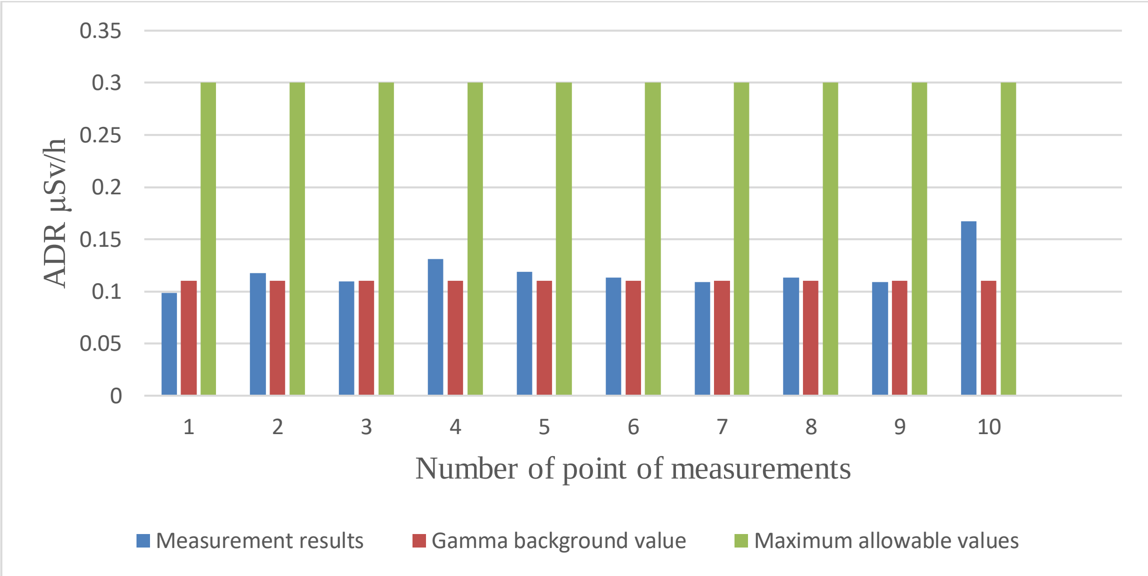


Figure 3.29 – Comparison of the measurement results in B1 with the background and maximum allowable value.

Despite the fact that the measured values of the absorbed dose rate at points 1-9 are close to the background values, the risk of developing cancer slightly exceeds the recommended value of $0,29 \cdot 10^{-3}$. The increase in the value at point 10 can be explained by the use of building materials during construction with an increased content of radionuclides.

## Chapter 4. Financial management

### 4.1 Potential consumers of research results

The purpose of the project work - to investigate gamma background in different atmospheric objects with potentially high radiation hazard. These facilities have people all year round who can receive high doses of radiation, in turn, these doses increase the risk of developing cancer.

In order to find out in which direction to conduct research, a consumer analysis was carried out.

Various research institutes and operational radiological services may show interest in the project.

Table 4.1 - Project stakeholders

| **Project stakeholders** | **Stakeholder expectations** |
|---|---|
| Research institutes | Obtaining data on the operation of several types of dosimeters in the field and research methods for other cities |
| Operational radiological services | Obtaining up-to-date information about the radiological situation around several socially significant objects of the technosphere |

Table 4.2 - Purpose and results of the project

| | |
|---|---|
| **Objectives of the project:** | The goal is to radiation survey area to determine the effect level of gamma radiation on the population of the city of Tomsk. |
| **Expected results of the project:** | 1. Carrying out a series of measurements using dosimeters of different types<br>2. Comparison of the experimental results for different detectors, conclusions about the effectiveness of their work and generalization of the research results. |
| **Acceptance criteria of the project result:** | 1. Correctness of data array processing<br>2. Availability of graphs with their description and analysis. |
| **Requirements for the project result:** | 1. The project must be completed by May 31, 2021.<br>2. The results obtained must meet the criteria for the acceptance of the project result.<br>3. The presence of a conclusion about the radiological situation in the central part of the city of Tomsk |

Project constraints and assumptions:

1. Funding source: government funding.
2. Project completion date: until 31.05.2021.
3. Time limit for TPU employees.

## 4.2 Analysis of competitive technical solutions

To analyze competitive technical solutions, experimental measurements were taken with detectors. The position of the development and competitors is assessed for each indicator by an expert way on a five-point scale, where 1 is the weakest position, and 5 is the strongest. The weights of the indicators, determined by expert, should add up to one.

The analysis of competitive technical solutions is determined by the formula:

$$К = \sum В_i \cdot Б_i \tag{4.1}$$

Where К – competitiveness of a scientific development or a competitor;

$В_i$ – indicator weight (in fractions of a unit);

$Б_i$ – weighted average of the *i*-th indicator;

$Бк_i$ – detector measurements.

Table 4.3 − Scorecard for comparing competitive technical solutions (developments)

| Criteria for evaluation | Criterion weight | Points | Competitiveness | |
|---|---|---|---|---|
| | | $Б_{к1}$ | $К_ф$ | $К_{к1}$ |
| Technical criteria for assessing resource efficiency | | | | |
| 1. Reliability of the received data | 0,3 | 4 | 1,2 | 1,2 |
| 2. No influence of atmospheric conditions on the experiment | 0,15 | 3 | 0,75 | 0,45 |
| 3. Experiment safety | 0,1 | 3 | 0,4 | 0,3 |
| 4. Ease of experimenting | 0,12 | 4 | 0,6 | 0,48 |
| 5. Time of data production | 0,1 | 3 | 0,3 | 0,3 |
| 6. Availability of expensive equipment | 0,05 | 3 | 0,25 | 0,15 |

Table 4.4 - Economic criteria for assessing efficiency

| | | | | |
|---|---|---|---|---|
| 1. Funding for scientific development | 0,05 | 2 | 0,25 | 0,1 |
| 2. Cost of materials | 0,1 | 2 | 0,5 | 0,2 |
| 3. Competitiveness | 0,03 | 4 | 0,12 | 0,12 |
| **Total** | 1 | 40 | 4,37 | 3,3 |

During the analysis of competitive technical solutions, a table was compiled (a scorecard for comparing competitive technical solutions).

### 4.3 SWOT analysis

SWOT- analysis – Strengths, Weaknesses, Opportunities and Threats – is a comprehensive analysis of a research project.

SWOT- analysis consists in describing the strengths and weaknesses of the project, in identifying opportunities and threats for the implementation of the project, which have manifested or may appear in its external environment.

Strengths are factors that characterize the competitive side of a research project. Strengths indicate that the project has a distinctive advantage or special resources that are special in terms of competition. In other words, strengths are the resources or capabilities that project management has and that can be effectively used to achieve the goals.

Weaknesses are a flaw, omission or limitation of a research project that hinders the achievement of its objectives. This is something that does not work well within the project or where it has insufficient capabilities or resources compared to competitors.

Opportunities include any preferable present or future situation that arises in the project's environment, such as a trend, change, or perceived need, that sustains demand for project outcomes and allows the project management to improve its competitive position. A threat is any undesirable situation, trend or change in the environmental conditions of a project that is destructive or threatening to its competitiveness in the present or future. The threat can be a barrier, restriction or anything else that can lead to problems, destruction, harm or damage to the project.

The table presents a SWOT analysis in the form of a table, also shows the results of the intersections of sides, opportunities and threats.

Table 4.5 - SWOT analysis

| | | |
|---|---|---|
| | Strengths of the research project:<br><br>–S1. Reliability of the received data;<br>–S2.The importance of measurements for the life and health of citizens;<br>–S3. The lack of similar studies;<br>–S4. Security of conducting research. | Weaknesses of the research project:<br><br>– W1. Lack of funding;<br>– W2. Long term for processing results;<br>–W3. Limited human resources make it impossible to survey vast territories. |
| Capabilities:<br><br>–B1. Using the innovative infrastructure of TPU.<br>–B2. The novelty of the research will lead to the emergence of stakeholders | Results of the analysis of the interactive matrix of the project fields "Strengths and Capabilities ":<br>1. Growth in demand for this type of research due to the spread among various organizations and universities.<br>2. Priority to this research in comparison with competitors due to the implementation of proper reliability and safety.. | Results of the analysis of the interactive matrix of the project fields "Weaknesses and Capabilities ":<br>1. Lack of a large number of orders for research.<br>2. Improvement of γ-detectors will lead to a decrease in the measurement error. |
| Threats:<br><br>– T1. High competition due to modernization of other devices;<br>– T2. Lack of funding from both the university and third-party enterprises | 1. High reliability coupled with low data cost significantly increases competitiveness;<br>2. Advantage over competitors due to the novelty of the idea. | 1.Research stagnation due to lack of funding;<br>2. A decrease in the cost of γ-detectors will allow the purchase of an additional number of detectors to expand the area of dose rate measurement, which will lead to an increase in demand for this technique. |

To identify the degree of need for strategic changes, an interactive matrix was built, presented in Table 4.6.

Table 4.6 - Interactive matrix

| Strengths of the research project | | | | | |
|---|---|---|---|---|---|
| Capabilities | | S1 | S2 | S3 | S4 |
| | B1 | + | + | 0 | + |
| | B2 | - | + | + | - |

Based on the data of the interactive matrix, we can conclude that the strengths of the project are associated with the capabilities of the external environment and thanks to them the project can be implemented and in demand on the market.

### 4.4 Research planning

#### 4.4.1 The structure of work in the framework of scientific research

Table 4.7 - List of stages, works and distribution of performers

| Main stages | № | Content of work | Duration days | Position of the performer |
|---|---|---|---|---|
| Development of technical specifications | 1 | Preparation and approval of technical specifications | 5 | Scientific supervisor, consultant of FM, SR, bachelor |
| Choosing a direction of research | 2 | Development of a research methodology | 3 | Supervisor, bachelor |
| | 3 | Choosing a direction of research | 20 | Supervisor, bachelor |
| | 4 | Scheduling of works by topics | 7 | Supervisor, bachelor |
| Theoretical and experimental research | 5 | Analysis of literary sources | 10 | Bachelor |
| | 6 | Practical calculation | 12 | Bachelor |
| Summarizing and Evaluating Results | 7 | Evaluation of the effectiveness of the results obtained | 6 | Supervisor, bachelor |
| | 8 | Determination of the feasibility of holding a FQP | 3 | Supervisor, bachelor |
| Carrying out the FQP | | | | |
| Development of technical documentation and design | 9 | Calculations and their analysis | 30 | Bachelor |
| | 10 | Evaluation of production efficiency and development application | 9 | Bachelor, FM Consultant |
| | 11 | Developing social responsibility on the topic | 8 | Bachelor, SR consultant |
| Registration of a set of documentation for FQP | 12 | Drawing up an explanatory note | 25 | Bachelor |
| **Total: 138 days** | | | | |

Draw up a Gantt chart based on the project schedule (Figure 4.1).

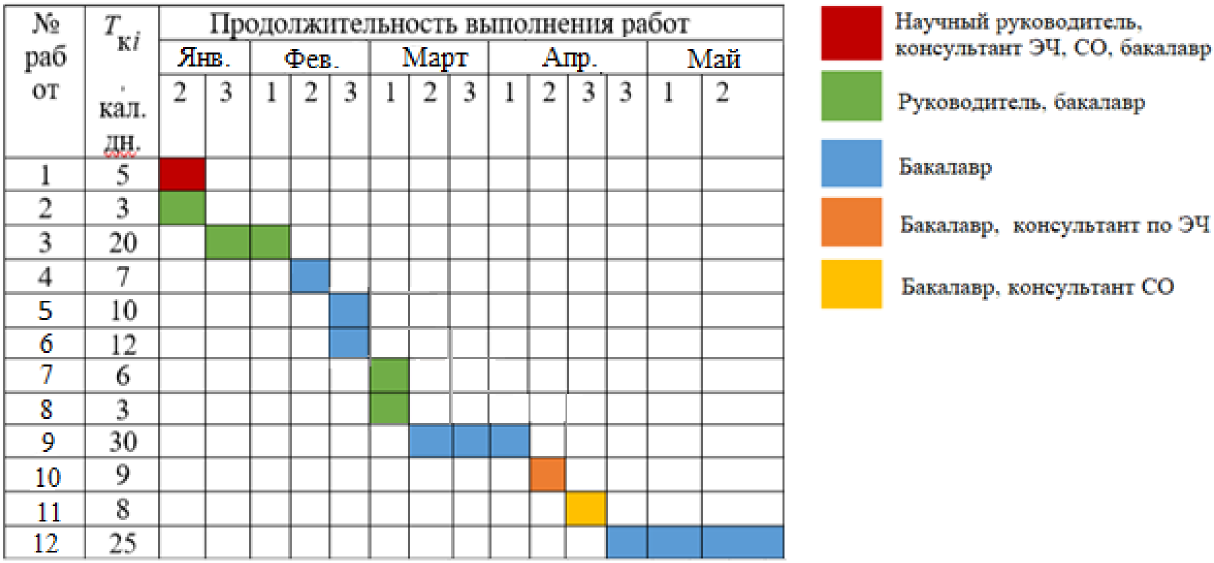


Figure 4.1 – Gantt chart

### 4.5 Project budget

When planning the project budget, a complete and reliable reflection of all types of costs associated with its implementation must be ensured.In the process of forming the project budget, the following grouping of costs by item is used:

1. Materials.
2. The cost of wages of employees.
3. Contributions to extrabudgetary funds.
4. Works performed by third parties.
5. Special equipment for scientific and experimental work.
6. Other direct costs.
7. Overhead costs.

Groups 1-7 relate to direct costs, the amount of direct costs, as a rule, should be determined by direct account, these are costs associated directly with the implementation of a specific scientific and technical research, the remaining costs are calculated indirectly, these are the costs of maintaining the administrative apparatus, general technical and general economic services, they are grouped together in the Overhead group.

#### 4.5.1 Material costs

To perform measurements, it is necessary to design a special detector based on a plastic scintillator.

Table 4.8 - Calculation of costs for the item "Development of equipment"

| № | Name of components | Стоимость |
|---|---|---|
| 1 | Scintillator BC-408 | 2500 rub. |
| 2 | Arduino Nano PCB | 500 rub. |
| 3 | Photomultiplier FEU-82 | 5000 rub. |
| 4 | Other components (voltage divider, wire capacitors, etc.) | 1000 rub. |
| | Итого | 9000 rub. |

The special equipment required for carrying out experimental work includes a laptop.

Laptop cost: 40,000 rubles. Service life: 5 years.

Depreciation deductions for the duration of the project:

$$A = \frac{40000 * 138}{1825} = 3025\ rub. \quad (4.2)$$

Table 4.9 - Calculation of costs for the item "Special equipment for scientific work"

| № | Equipment | Days of operation | Life time | Cost | Depreciation deductions |
|---|---|---|---|---|---|
| **1** | Computing technology, laptop | 138 | 5 лет | 40000 | 3025 rub. |
| | **Total** | | | | **3025 rub.** |

### 4.5.2 Basic salary

The amount of wage costs is determined based on the labor intensity of the work performed and the current remuneration system. The basic salary includes a bonus paid monthly from the payroll (the amount is determined by the Regulations on Labor Remuneration).

The salary of the project performer is calculated by the formula:

$$С_{зп} = З_{осн} + З_{доп} \quad (4.3)$$

where $З_{осн}$ – basic salary;

$З_{доп}$ – additional wages.

Basic salary ($З_{осн}$) of the project performer is calculated by the following formula:

$$З_{осн} = З_{дн} \cdot Т_{раб} \quad (4.4)$$

where $З_{осн}$ – basic salary of one employee;

$Т_{раб}$ – duration of work performed by a scientific and technical worker, working days;

$З_{дн}$ – average daily wage of an employee, rub.

Average daily wages are calculated using the formula:

$$З_{дн} = \frac{З_м \times М}{F_д} \qquad (4.5)$$

where $З_м$ – employee's monthly salary, rub.;

М – the number of months of work without vacation during the year: with a vacation of 48 work. days М = 10.4 months, 6-day week;

$F_д$ – actual annual fund of working time of scientific and technical personnel, working days

Table 4.10 – Balance of working hours

| **Working time indicators** | **Scientific adviser** | **Student** |
|---|---|---|
| Calendar number of days | 365 | 365 |
| Number of non-working days<br>- weekends<br>- holidays | 19<br>6 | 19<br>6 |
| Lost working time<br>- vacation<br>- sick absence | 48 | 48 |
| Valid annual working time fund | 251 | 251 |

Employee's monthly salary:

$$З_м = З_б \cdot (1 + k_{пр} + k_д) \cdot k_р, \qquad (4.6)$$

where $З_б$ – base salary, rub.;

$k_{пр}$ – premium coefficient equal to 0,3;

$k_д$ – the coefficient of surcharges and allowances is approximately 0,2 – 0,5;

$k_р$ – – regional coefficient equal to 1.3 (for Tomsk).

Table 4.11 – The calculation of the basic salary

| **Performers** | **Salary, rub** | ***k*р** | **Зм, руб** | **Здн,руб.** | **Тр,раб.дн.** | **Зосн,руб.** |
|---|---|---|---|---|---|---|
| Scientific adviser | 30847 | 1,3 | 40101,1 | 1 662 | 86 | 142932 |
| Student (engineer) | 17890 | | 23257 | 964 | 136 | 131104 |
| **Total:** | | | | | | **274036** |

### 4.5.3 Additional salary

This group includes the amount of payments provided for by labor legislation, for example, payment of regular and additional vacations; payment of time associated with the performance of state and public duties; payment of remuneration for seniority, etc. (on average - 12% of the basic salary).

Additional salary is calculated on the basis of 10-15% of the basic salary of employees directly involved in the performing of threads:

$$З_{доп} = k_{доп} \cdot З_{осн} \qquad (4.7)$$

where $З_{доп}$ – additional salary, rub.;

$k_{доп}$ – additional salary coefficient equal to 0,12;

$З_{осн}$ – basic salary, rub.

Table 4.12 – Salaries of project performers

| Salary | Scientific adviser | Student |
|---|---|---|
| Basic salary, rub. | 142932 | 131104 |
| Additional salary, rub. | 17152 | 15733 |
| **Total, rub:** | **306921** | |

#### 4.5.4 Contributions to extrabudgetary funds

This group reflects the obligatory deductions according to the norms established by the legislation of the Russian Federation to the state social insurance bodies (FSS), the pension fund (PF) and medical insurance (FFOMS) from the costs of salary of employees.

The amount of contributions to extrabudgetary funds is determined based on the following formula:

$$C_{\text{внеб}} = k_{\text{внеб}} \cdot (З_{\text{осн}} + З_{\text{доп}}) \tag{4.8}$$

where $k_{\text{внеб}}$ – coefficient of deductions for payment to extra-budgetary funds equal to 30.2%.

The amount of contributions to extrabudgetary funds is determined based on the following formula:

$$З\text{внеб} = \text{kвнеб} * \sum(З\text{осн} + З\text{доп}) = 0{,}302 * 306921 = 92690 \text{ rub.} \tag{4.9}$$

#### 4.5.5 Overheads

This group includes management and maintenance costs. In addition, this includes the costs of maintaining, operating and repairing equipment, production tools and inventory, buildings, structures, etc.

Overhead costs are 30% of the amount of basic and additional salary of employees directly involved in the implementation of scientific research.

$$C_{накл} = k_{накл} * (З_{осн} + З_{доп}) = 0,3 * 306921 = 92076 \text{ rub.} \quad (4.10)$$

where $k_{накл}$ – overhead coefficient.

### 4.5.6 Other direct costs

В данной статье расходов рассматриваются затраты на электроэнергию, потребляемую оборудованием, которые рассчитываются по формуле:

$$C = T_{эл} \cdot P \cdot t_{об} \quad (4.11)$$

where $_{эл}$ – electricity tariff (5.8 rubles per 1 kWh);

$P$ – equipment power, kW;

$t_{об}$ – time of equipment use, h.

Table 4.13 – Calculation of other direct costs

| Equipment | Working time, h | Power consumption of electricity, kW | Price for 1 kW, rub. | Electricity costs (Зэ), rub. |
|---|---|---|---|---|
| Computer | 276 | 0,5 | 5,8 | 348 |
| **Total:** | | | | **348 руб.** |

The calculated amount of research costs is the basis for the formation of the project cost budget. Determination of the cost budget for a research project for each implementation option is shown in the table.

Table 4.14 – Project cost budget

| **Article title** | **Amount,rub.** |
| --- | --- |
| Equipment development costs | 9000 |
| Special equipment costs | 3025 |
| Costs for the basic salary of performers | 274036 |
| Costs of additional salaries of performers | 32883 |
| Contributions to extrabudgetary funds | 92690 |
| Overheads | 92076 |
| Other direct costs | 348 |
| **Project cost budget** | **504057** |

The planned cost of the project is 504057 rubles.

### 4.6 Determination of the resource (resource-saving), financial, budgetary, social and economic efficiency of the research

Determination of efficiency is based on the calculation of the integral indicator of the effectiveness of scientific research. Its finding is associated with the determination of two weighted averages: financial efficiency and resource efficiency.

The integral financial development indicator is defined as:

$$I_{фин}^{испi} = \frac{Ф_{pi}}{Ф_{max}}, \qquad (4.12)$$

where $I_{фин}^{испi}$– integral financial development indicator;

$Ф_{pi}$ – cost of the *i*-th version;

$Ф_{max}$ – maximum cost of performing of a research project (including analogues).

The resulting value of the integral financial development indicator reflects the corresponding numerical increase in the development cost budget in times (the value is greater than one), or the corresponding numerical reduction in the development cost in times (the value is less than one, but greater than zero).

Since the development has one version, then:

$$I^{исп}_{фин} = 1 \qquad (4.13)$$

The integral indicator of resource efficiency of variants of the research object can be determined as follows:

$$I_{pi} = \sum a_i \cdot b_i, \qquad (4.14)$$

where $I_{pi}$ – integral indicator of resource efficiency for the *i*-th;

$a_i$ – weighting factor of the *i*-th design option;

$b_i$ – the point estimate of the *i*-th variant of the development, is established by an expert according to the selected rating scale.

The calculation of the integral indicator of resource efficiency is presented in the form of a table.

Table.4.15 – Assessment of the characteristics of project performing

| Criteria | Parameter weighting factor | Evaluation |
|---|---|---|
| 1. Promotes increased user productivity | 0,23 | 5 |
| 2. Ease of use | 0,10 | 5 |
| 3. Interference immunity | 0,20 | 4 |
| 4. Energy saving | 0,20 | 3 |
| 5. Reliability | 0,12 | 4 |
| 6. Material consumption | 0,15 | 4 |
| Total | 1 | |

$$I_{pi} = 5 \cdot 0{,}23 + 5 \cdot 0{,}1 + 4 \cdot 0{,}2 + 3 \cdot 0{,}2 + 4 \cdot 0{,}12 + 4 \cdot 0{,}15 = 4{,}13 \qquad (4.15)$$

Integral indicator of the effectiveness of development options ($I_{испi}$) is determined on the basis of the integral indicator of resource efficiency and the integral financial indicator according to the formula:

$$I_{испi} = \frac{I_{р-испi}}{I_{финр}^{испi}}, \qquad (4.16)$$

Comparative project effectiveness ($Э_{ср}$):

$$Э_{ср} = \frac{I_{исп1}}{I_{исп2}}, \qquad (4.17)$$

Table 4.16 – Development efficiency

| **№** | **Indicators** | **Evaluation** |
|---|---|---|
| 1 | Integral financial development indicator | 1 |
| 2 | Integral indicator of resource efficiency | 4,13 |
| 3 | Integral efficiency indicator | 0,24 |

Comparison of the values of integral performance indicators allows us to understand and choose a more effective solution to the technical problem posed from the standpoint of financial and resource efficiency. In this case, it has only one solution to the problem. Therefore, the option provided is assumed to be the best.

## 4.7 Conclusions by section

As a result of fulfilling the objectives of the section, the following conclusions can be drawn:

– the market in which the provided service is in demand has been determined.

– an analysis of competitors was carried out

– in the course of planning, a schedule for the implementation of the work stage was developed for the manager and the engineer, which allows you to estimate and plan the working hours of the performers. The days from the schedule are determined, when and how much the manager and engineer work.

– to estimate the costs of the project, a project budget has been developed, which is 504057 rub.

– based on the data obtained and the analysis of efficiency, it can be concluded that the selected version of the execution is the most effective from the standpoint of resource efficiency.

In the completed final qualifying work, economic and technical criteria of efficiency were achieved due to the functional capabilities of the development, as well as social ones due to the demand for such technology on the market.

## Chapter 5. Social responsibility

Radiation monitoring of the environment is intended to ensure the protection of the population from the harmful effects of ionizing radiation on their health. One of the most important criteria for assessing the degree of radiation exposure is the radiation dose. The radiation dose to the public is controlled only by external gamma radiation, which is emitted by natural sources such as space and earth. For urban residents, objects of the technosphere are an additional source of radiation. Therefore, the assessment of gamma background in the urban environment is an important aspect of the radiological protection of the population.

Materials of natural origin that have an increased gamma background and are used as construction and finishing materials for buildings and urban infrastructure facilities, industrial facilities that cause pollution of surrounding areas with materials used in technological processes, as well as features of the terrain ( natural and artificial) affecting the amount of radiation background.

Purpose to this work is a radiation survey of such facilities and areas to determine the effect level of gamma radiation on the population. To carry out this work, it was necessary to carry out several measurements in different parts of the city of Tomsk. Then analyze the results obtained, highlight certain patterns and draw a conclusion about the radiation hazard of monuments and art objects.

The section deals with the dangerous and harmful factors affecting the student who is in the 122 classroom of the 10th TPU building, factors influencing the research process, legal and organizational issues, as well as measures in emergency situations.

## 5.1 Legal and organizational security issues

The main provisions on labor protection are set out in the Labor Code of the Russian Federation [15]. This document states that protecting the health of workers, ensuring safe working conditions, eliminating occupational diseases and industrial injuries are one of the priority tasks of the state.

According to the previously mentioned document, each employee has the right to:

– workplace that meets labor protection requirements;

– compulsory social insurance against industrial accidents and occupational diseases;

– obtaining reliable information from your own employer, relevant government agencies and public organizations on the conditions and labor protection at the workplace, on the existing risk of damage to health, as well as on measures to protect against exposure to harmful and (or) hazardous production factors;

– refusal to perform work in case of danger to his life and health due to violation of labor protection requirements;

– provision of means of individual and collective protection in accordance with labor protection requirements at the expense of the employer;

– training in safe working methods and techniques at the expense of the employer;

– personal participation or participation through their representatives in the consideration of issues related to ensuring safe working conditions at his workplace, and in the investigation of an industrial accident or occupational disease that occurred to him;

– extraordinary medical examinations in accordance with medical recommendations to preserve his place of work (position) and average earnings during the passage of the said medical examination;

– guarantees and compensations established in accordance with this Code, a collective agreement, an agreement, a local normative act, an employment contract, if he is employed in work with harmful and (or) dangerous working conditions.

In [15], it is said that the normal duration of working hours cannot exceed 40 hours per week, the employer is obliged to keep records of the time worked by each employee.

### 5.2 Basic ergonomic requirements for the correct location of the researcher's workplace when working with a PC

The rational layout of the workplace provides for a clear order and consistency in the placement of items, labor tools and documentation. The workplace when working with a PC should be at least 6 square meters. Legroom must comply with the following parameters: legroom height - at least 600 mm, seat distance to the bottom edge of the working surface - not less than 150 mm, seat height - 420 mm. It should be noted that the height of the table should depend on the height of the operator [16].

The following requirements are also imposed on the organization of the workplace of the PC user: the design of the working chair should ensure the maintenance of a rational working posture when working at the PC and allow changing the posture to reduce the static tension of the muscles of the neck, shoulders and back to prevent the development of overwork.

The type of work chair should be selected taking into account the height of the user, the nature and duration of work with the PC. The working chair should be lifting and swiveling, adjustable in height and angle of the seat and backrest, as well as the distance of the backrest from the front edge of the seat, while the adjustment of each parameter should be independent, easy to implement and have reliable fixation [17].

With monotonous mental work that requires significant nervous tension and great concentration, it is recommended to choose dull, low-contrast floral shades that do not scatter attention (low-saturated shades of cold green or blue colors). For work that requires intense mental or physical stress, warm shades are recommended that stimulate human activity.

### 5.3 Industrial safety

#### 5.3.1 Analysis of harmful and dangerous factors

A hazardous production factor according to [18] is a production factor, the impact of which, under certain conditions, leads to injury or other sudden, sharp deterioration in health.

A harmful production factor is such a factor, the effect of which on a worker in certain conditions leads to illness or a decrease in working capacity.

The research work was carried out on a computer indoors (when analyzing the results), as well as in an urban environment (when collecting data). Working conditions at the workplace are characterized by the presence of hazardous and harmful factors, which are classified into groups of elements: physical, chemical, biological, psychophysiological. Below in table 5.1 are presented the dangerous and harmful factors present when working with the PC 122 of the room 10 of the TPU building.

Table 5.1 - Main hazardous and harmful factors

| Факторы | Нормативные документы |
|---|---|
| 1. Deviation of microclimate indicators. | SanPiN 2.2.4.548-96. Hygienic requirements for the microclimate of industrial premises. |
| 2. The increased level of electromagnetic radiation | GOST 12.1.006 - 84 SSBT. Radio frequency electromagnetic fields. General safety requirements. |
| 3. Insufficient illumination of the working area | SanPiN 2.2.1 / 2.1.1.1278-03. "Hygienic requirements for natural, artificial and combined lighting of residential and public buildings." |
| 4. Excessive noise level | CH 2.2.4 / 2.1.8.562-96. "Noise at workplaces, in residential, public buildings and on the territory of development." |
| 5. Psychophysiological factors | SanPiN 2.2.2 / 2.4.1340-03. "Hygienic requirements for personal electronic computers and work organization." |

| | |
|---|---|
| 6. Electric shock | GOST 12.1.038–82 SSBT. "Electrical safety. Maximum permissible levels of touch voltages and currents. " |
| 7. Exposure to ionizing radiation | SanPiN 2.6.1.2523-09 "Standards of radiation safety (NRB-99/2009)" |
| 8. Possibility of fire | SNiP 21-01-97. "Fire safety of buildings and structures" |

### 5.3.2 Deviation of microclimate indicators

The air of the working area (microclimate) of industrial premises is determined by the following parameters: temperature, relative humidity, air velocity. Optimal and permissible values of microclimate characteristics are set in accordance with the norms [19] and are shown in Table 5.2.

Table 5.2 - Optimal and permissible microclimate parameters

| Period of the year | Air temperature, °C | Relative humidity, % | Air speed, m / s |
|---|---|---|---|
| Cold | 23 – 25 | 40 – 60 | 0,1 |
| Warm | 22 – 24 | 40 | 0,1 |

Deviation of microclimate indicators from the norm does not cause damage or health disorders, but can lead to the occurrence of general and local sensations of thermal discomfort, tension of thermoregulatory mechanisms, deterioration of well-being and a decrease in working capacity.

Ventilation is used to ensure the established norms of microclimatic parameters and air purity at workplaces and rooms. General exchange ventilation is used to provide an appropriate microclimate in the premises. The air humidity should be monitored periodically. In the summertime, air conditioning systems must be used when the outside temperature is high.

The following volumes of outdoor air must be supplied to the room: with a room volume of up to 20 $m^3$ per person - at least 30 $m^3$ per hour per person; if the volume of the room is more than 40 $m^3$ per person and there is no emission of harmful substances, natural ventilation is allowed [19].

The area of the room where the work was carried out is 33 $m^2$, the volume is 99 $m^3$, the air exchange rate is 3 1 / h. Consequently, the air exchange in the room is 297 $m^3$ / h. For this value of air exchange, a single-stage blower SB-0310 D0 is suitable, the average capacity of which is 330 $m^3$ / h, and the maximum capacity is 530 $m^3$ / h.

The heating system must provide sufficient, constant and uniform heating of the air. In rooms with increased requirements for air purity, water heating should be used. The microclimate parameters in the laboratory used are regulated by the central heating system.

### 5.3.3 Increased level of electromagnetic radiation

The screen and computer system units produce electromagnetic radiation. Most of it comes from the system unit and video cable. The strength of the electromagnetic field at a distance of 50 cm around the screen in terms of the electrical component should correspond to Table 3. An increased level of electromagnetic radiation can negatively affect the human body, namely, lead to nervous disorders, sleep disturbances, significant deterioration of visual activity, weakening of the immune system, cardiovascular disorders vascular system [21].

Table 5.3 - Permissible levels of parameters of the electromagnetic field

| Description of characteristics | | The value of the permissible level |
|---|---|---|
| Electromagnetic field strength | Frequency range 5 Hz - 2kHz | 25 V / m |
| | Frequency range 2 kHz –400 kHz | 2,5 V / m |
| Magnetic flux density | Frequency range 5 Hz –2 kHz | 250 nT |
| | Frequency range 2 kHz – 400 kHz | 25 nT |

According to the document [21], there are the following methods of protection against EMI:

– increasing the distance from the source (the screen must be at least 50 cm away from the user);

– the use of screen filters, special screens and other personal protective equipment.

### 5.3.4 Insufficient illumination of the working area

Fatigue of the organs of vision can be associated with both insufficient illumination and excessive illumination, as well as with the wrong direction of light.

According to the standards [22], the illumination on the table surface in the area of the working document should be 300–500 lx. The lighting should not create glare on the surface of the screen. The illumination of the screen surface should not exceed 300 lux.

The brightness of general lighting luminaires in the area of radiation angles from 50 to 90 ° with the vertical in the longitudinal and transverse planes should be no more than 200 cd / m, the protective angle of the luminaires should be at least 40 °. The safety factor (Кз) for lighting installations of general lighting should be taken equal to 1.4. The ripple factor should not exceed 5%.

Artificial lighting in rooms for the operation of a PC should be carried out by a system of general uniform lighting. In industrial and administrative-public premises, in cases of predominant work with documents, the following systems should be used: combined lighting (lamps are additionally installed in addition to general lighting; local lighting designed to illuminate the area where documents are located).

The main way to protect against insufficient lighting is to comply with the lighting standards [23]. In a room with III grade of visual work with high accuracy, the illumination should be 200 lux, and the ripple coefficient should be 15%. The pulsations of illumination are due to the low inertia of the radiation of gas-discharge lamps, the luminous flux from which pulsates at an alternating current of industrial frequency.

The number of luminaires for the room is calculated:

$$n = \frac{E * S * Z * K}{F * U * m} \tag{5.1}$$

где E – normalized illumination, E = 300 lux;

S – room area, , S= 297 m$^2$;

Z – correction factor of the luminaire, Z=1,2;

K – safety factor, К=1,2;

F – luminous flux of one lamp, ЛД 40, F=2130 lux;

U – utilization rate, U=0,55;

m – number of lamps in the luminaire, m=2,

$$n = \frac{300 * 297 * 1,2 * 1,2}{2130 * 0,55 * 2} = 54,76 \text{ pieces} \qquad (5.1)$$

To ensure a sufficient level of illumination, it is necessary to round the resulting value to a larger integer, i.e. up to 55 pieces.

Organization of the workplace can protect against insufficient lighting. Illumination of the workplace should be uniform. The work table should be located in a well-lit area, preferably by a window. The person at the table should be facing or left side to the window (right-handed). Artificial light fixtures should be located relative to the human body in the same way [23].

### 5.3.5 Excessive noise level

Noise, being a general biological stimulus, affects not only the auditory analyzer, but also affects the structures of the brain, causing shifts in various functional systems of the body. Among the many manifestations of the adverse effects of noise on the human body are: decreased speech intelligibility, unpleasant sensations, the development of fatigue and a decrease in labor productivity, the appearance of noise pathology. Noise can be generated by operating equipment, air conditioning units, daylight fixtures, and can also be emitted from outside. When performing work on a PC, the noise level at the workplace should not exceed 50 dB.

The table shows the noise level norms for various types of work [18].

Table 5.4 - Noise levels for various types of work

| | Maximum permissible noise level (dB), in bands of the next octaves (Hz) | | | | | | | | | Equivalent noise levels, dBA |
|---|---|---|---|---|---|---|---|---|---|---|
| Scientific work, calculations, design | 86 | 71 | 61 | 54 | 49 | 45 | 42 | 40 | 38 | 50 |
| Offices, laboratories | 93 | 79 | 70 | 68 | 58 | 55 | 52 | 52 | 49 | 60 |

In 122 auditoriums of the 10th TPU building, the main source of noise is the PC cooling systems. These systems consist of CPU coolers and graphics card fans. For the Dell Inspiron 17R laptop, the overall noise level is 30dB, which eliminates the need for additional protection during operation.

### 5.3.6 Psychophysiological factors

Psychophysiological hazardous and harmful production factors are divided into: physical overload (static, dynamic) and neuropsychic overload (mental overstrain, monotony of work, emotional overload)

The labor activity of workers in the non-production sphere belongs to the category of work associated with the use of large amounts of information, with the use of computerized workplaces, with frequent decision-making in the face of a shortage of time, direct contact with people of different types of temperament, etc. This causes a high level of neuropsychic overload, reduces the functional activity of the central nervous system, leads to disorders in its activity, the development of fatigue, overwork, stress.

The most effective means of preventing fatigue when working in production are means that normalize a person's active labor activity. Against the background of the normal course of production processes, one of the important physiological measures against fatigue is the correct mode of work and rest [26].

### 5.3.7 Electric shock

In terms of the risk of electric shock, the workplace can be classified as class 2, i.e. this is a room without increased danger due to the possibility of simultaneous contact of a person to the metal structures of buildings, technological devices, mechanisms, etc., connected to the ground, on the one hand, and to the metal cases of electrical equipment, on the other [24].

There is a danger of electric shock in the following cases:

– in direct contact with live parts during repair;

– when touching non-conductive parts that are energized (in case of violation of the insulation of conductive parts);

– when touching the floor, walls that are energized;

– short circuit in the high-voltage units: power supply unit and a display unit scanning

The degree of dangerous effects of electric current on the human body depends on::

– type and magnitude of voltage and current;

– frequency of electric current;

– paths of current flow through the human body;

– duration of exposure to the human body;

– environmental conditions.

Electric current has a thermal, electrolytic, mechanical and biological effect on a person.

The thermal effect of the current manifests itself in burns, heating of blood vessels and other organs, as a result of which functional disorders arise in them.

The electrolytic effect of the current is characterized by the decomposition of blood and other organic fluids, which causes disturbances in their physicochemical composition.

The mechanical action of the current manifests itself in damage (rupture, stratification, etc.) of various tissues of the body as a result of the electrodynamic effect.

The biological effect of the current on living tissue is expressed in the dangerous excitation of the cells and tissues of the body, accompanied by involuntary convulsive muscle contractions. As a result of such excitement, a violation and even complete cessation of the activity of the respiratory and circulatory organs can occur.

The main measures for protection against electric shock are:

– ensuring the inaccessibility of live parts by using insulation in equipment cases;

– the use of means of collective protection against electric shock;

– use of protective grounding, protective shutdown;

– use of uninterruptible power supplies.

The technical methods and means are used separately or in combination with each other so as to provide optimal protection.

Organizational measures for electrical safety are periodic and unscheduled briefings. Periodic briefing is provided to all non-electrical personnel performing the following work: turning on and off electrical appliances, cleaning rooms near electrical panels, sockets and switches, etc. All non-electrical personnel must be certified for the first qualification group for electrical safety. Periodic briefing is carried out at least once a year [24].

An unscheduled briefing is carried out by the head of the department during the commissioning of new technical electrical equipment.

#### 5.3.8 Exposure to ionizing radiation

Ionizing radiation is radiation that can ionize molecules and atoms. This effect is widely used in energy and industry. At the same time, it carries a significant health hazard.

While passing through living tissue, this radiation can damage cells, resulting in two types of effects. Deterministic effects (harmful tissue reactions) due to exposure to high doses and stochastic effects due to DNA destruction and mutations (eg cancer induction).

To ensure radiation safety when using sources of ionizing radiation, it is necessary to be guided by the following principles:

а) maintain individual radiation doses from all radiation sources not exceeding the permissible exposure;

б) prohibit any activity using radiation sources if the profit is less than the risk of a possible hazard;

в) maintain at a minimum level of individual radiation doses from all radiation sources.

When working with ionizing radiation, two groups of people are distinguished: personnel working with ionizing radiation and the population.

The effective dose for personnel should not exceed 1000 mSv for 50 years of work, and for the population should not exceed 70 mSv for 70 years of life. In addition, there is an equivalent dose limit of 1 mSv per month to the lower abdomen for female personnel under 45 years of age. During pregnancy and lactation, women should not work with radiation sources. For students over 16 years old who use radiation sources in the educational process or are in rooms with an increased level of ionizing radiation, the dose limits are a quarter of the personnel dose limits [25].

### 5.3.9 Fire and explosive safety

According to the explosion and fire hazard, the premises are divided into categories А, Б, В1 – В4, Г и Дand buildings - into categories А, Б, В, Г и Д. Categories of premises and buildings are determined based on the type of combustible substances and materials in the premises, their quantity and fire hazard properties, as well as on the basis of the space-planning solutions of the premises and the characteristics of the technological processes carried out in them [27].

The room in which this work is performed, according to the degree of explosion and fire, belongs to category B3, as it contains solid, flammable substances.

Possible causes of fire:

– short circuits in the power supply;

– work with open electrical equipment;

– malfunction of current-carrying parts of installations;

– non-observance of fire safety rules;

– presence of combustible components: doors, tables, cable insulation, etc.

Fire prevention measures are divided into: technical, operational, organizational, and regime.

Technical measures include: compliance with fire regulations, norms in the design of buildings, in the installation of electrical wires and equipment, heating, ventilation, lighting, correct placement of equipment, etc.

Operational activities include timely preventive inspections, repair and testing of technological equipment, etc.

Organizational measures provide for the correct operation of equipment, the correct maintenance of buildings and territories, fire-prevention instructions for workers and employees, training of production personnel in fire safety rules, the publication of instructions, posters, an evacuation plan, etc. [28].

Regime measures include the establishment of rules for organizing work and compliance with fire-prevention measures.

In the event of an emergency, it is necessary:

1. Report to the management (duty officer).

2. Call the appropriate emergency service or the Ministry of Emergency Situations - tel. 112.

3. Take measures to eliminate the accident according to the instructions.

### 5.4. Analysis of a typical emergency during the study

An emergency situation is a situation in a certain territory resulting from an accident, a dangerous natural phenomenon, a catastrophe, the spread of a disease that poses a danger to others, a natural or other disaster that may or have resulted in loss of life, damage to human health or the environment, significant material losses and violation of the living conditions of people. There are two types of emergencies: man-made and natural.

Man-made emergencies include fires, explosions, sabotage, emissions of toxic substances. Natural disasters include natural disasters. The most probable man-made emergencies are fires.

The dangers of an accident include a sudden and uncontrollable source of energy: a moving object, uncontrollable movement or energy [26].

Let's consider possible emergencies in TPU building No. 10 in room 122, namely:

– Falling from your own height;

– Electric shock;

– Fire breakout.

Measures to prevent and eliminate the above emergencies are presented in Table 5.5

Table 5.5 - Emergency situations

| Emergency situation | Prevention measures | Emergency response measures |
|---|---|---|
| Falling from the height of one's own growth | 1. Maintenance of the premises in proper order.<br>2. Work space limitation.<br>3. Timely briefing. | 1. Examine or interview the victim;<br>2. If necessary, call an ambulance (112,103);<br>3. Stop bleeding, if any;<br>4. If there is a suspicion that the victim has a broken spine (sharp pain in the spine with the slightest movement), it is necessary to provide the victim with complete rest in the |

| | | |
|---|---|---|
| | | supine position until qualified medical care is provided. |
| Electric shock | 1. Grounding of all electrical installations.<br>2. Work space limitation<br>3. Ensuring the inaccessibility of live parts of the equipment.<br>4. Timely briefing. | 1. Quickly release the victim from the electric shock;<br>2. Call an ambulance (112,103);<br>3. If the victim has lost consciousness, but breathing has been preserved, he should be comfortably laid down, unfastened clothing, create an influx of fresh air and ensure complete rest;<br>4. Victim should be allowed to smell ammonia, sprinkle water on his face, rub and warm the body. |
| Fire | 1. Timely briefing.<br>2. Installation of automatic fire extinguishing equipment in premises.<br>3. Installing smoke and fire detectors.<br>4. Providing escape routes and maintaining them in proper condition.<br>4. Monitoring the operation of electrical appliances. | 1. De-energize the room, cut off the air supply;<br>2. Immediately report the fire to the duty officer or to the security post;<br>3. If possible, take measures to evacuate people, extinguish a fire and save material assets. |

## 5.5 Section Conclusions

In this chapter, harmful and hazardous factors were identified, formed during the analysis of the data of measurements of the gamma background on a PC, among which are:

– noise [18];

– microclimate [19];

– EMF [20];

– ionizing radiation [25].

It was found that auditorium 122 of 10 building of TPU:

– belongs to category 1 for electrical safety (up to 1000 V) [24];

– belongs to the class "moderately fire hazardous" for fire and explosion safety [28].

Methods of reducing the impact of harmful and dangerous factors on the researcher are described. The last subsection analyzes possible emergencies. Also described are measures to prevent them and measures to eliminate the consequences of emergencies. The most likely emergency is the occurrence of a fire in the workplace due to equipment fires.

## Conclusion

During the work was carried out literature review for assessing the methods and results of such measurements made in other Russian cities. Dosimetric devices designed to measure the level of gamma background and used in this work have been studied.

A series of measurements were carried out at points located in the immediate vicinity of the objects of the technosphere and at some distance from these objects. The following instruments were used for measurements: wide-range dosimeter DRG-01T1, the absolute measurement error of which was 27%, dosimeter-radiometer DRBP-03 with an error of 16%, and a scintillation detector based on a plastic scintillator BC-408 with an error of 13%.

It was found that the granite embankment (sections H1, H3 and H4) is the area with the highest recorded gamma background radiation. The maximum values of the measured power of the subscriber equivalent dose of gamma radiation were 0.27 μSv/h, 0.22 μSv/h, 0.28 μSv/h. In the H1 area, an increased gamma background is observed throughout the study area. Average ADR values for the studied areas were: for the granite embankment 0.191 μSv/h, for the monument "400 years of Tomsk" 0.089 μSv/h, in the Karl Marx square 0.108 μSv/h and on the embankment of the river. Tom 0.119 μSv/h.

The calculated annual effective dose equivalent shows that these zones do not have a direct radiological effect on the health of the population, but there is a very high probability of developing cancer in a person staying in these areas for more than 4.8 hours a day. It follows from this that in order to reduce harm to health, it is necessary to limit the time spent in these territories.

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